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REPORT FOR THE CONFERENCE ON POLLUTION OF RARITAN BAY AND ADJACENT INTERSTATE WATERS. THIRD SESSION, VOLUME III. APPENDICES

Federal Water Pollution Control Administration
Metuchen, New Jersey

May 1967

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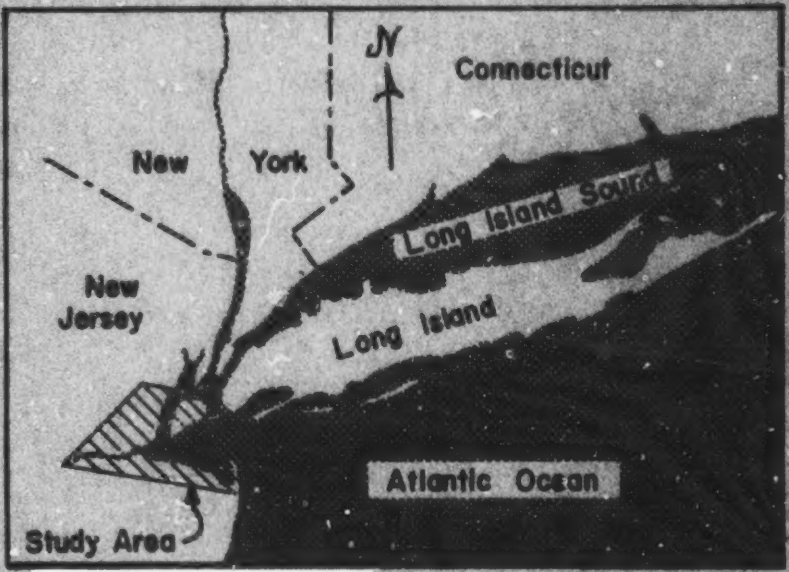
PB 218 089

# REPORT
for
THE CONFERENCE ON POLLUTION OF RARITAN BAY AND ADJACENT INTERSTATE WATERS

THIRD SESSION

VOLUME III-APPENDICES


N
Connecticut
New
York
Long Island Sound
New Jersey
Long Island
Atlantic Ocean
Study Area

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NORTHEAST REGION - RARITAN BAY PROJECT
METUCHEN, N.J.
MAY 1967

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REPORT

for

THE CONFERENCE ON POLLUTION OF RARITAN BAY AND ADJACENT INTERSTATE WATERS

THIRD SESSION

VOLUME III-APPENDICES

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NORTHEAST REGION - RARITAN BAY PROJECT
METUCHEN, N.J.
MAY 1967

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE, BUREAU OF STATE SERVICES

Division of Environmental Engineering and Food Protection

Shellfish, Sanitation Branch
NORTHEAST RESEARCH CENTER
Narragansett, Rhode Island

A Report on the
SHELLFISH RESOURCES OF RARITAN BAY, NEW JERSEY

Prepared by

Robert Campbell
Marine Research Biologist

2 July 1964

(Revised May 1965)

A REPORT ON THE SHELLFISH RESOURCES OF RARITAN BAY

Abstract

Cases of infectious hepatitis traced to clams harvested from Raritan Bay in 1961 stimulated a cooperative State-Public Health Service study of water and shellfish sanitary quality in the bay.

The present report describes the distribution of only two species of clams, the Soft Shell Clam, *Mya arenaria*, and the Northern Quahaug, *Mercenaria mercenaria*. Quantitative features of population sampling permitted statistical evaluation of the clam resource of Raritan Bay. This information, coupled with the bacteriological information being processed for a separate report, describes the clam-water relationship in Raritan Bay.

Density-distribution charts illustrate the diverse patterns of array found in the northern and southern sectors of the bay. A more evenly and widely distributed population is evident on the New York side while the contrasting New Jersey population is notably spotty in appearance. The distribution of these shellfish is further emphasized by this survey and is no doubt related to hydrographic and substrate conditions inherent in the bay.

Consideration of the population on a state basis shows that New York posseses the greater density of quahaugs (hard shell clams) —— 1.05 individuals per square foot compared with 0.47 for New Jersey. In the standing crop estimates, New York contains almost a three-to-one ratio in millions of bushels over New Jersey.

Quantitative estimates for the various size categories show that "large" size quahaugs are two times more abundant than "necks" "Sub-legals" are the least abundant.

Soft Shell Clams appeared to be more abundant in the deeper waters. The majority of those in the western sector of Raritan Bay and coves of Sandy Hook were of smaller size compared with other areas of the bay. Instances of 50 or more individuals per square foot were not an uncommon occurrence.

A REPORT ON THE SHELLFISH RESOURCES OF RARITAN BAY

INTRODUCTION

Historical reviews of natural resources in estuarine environments recount the decline of the resource as being directly proportional to an increase of both domestic and industrial pollution. Over the years, however, it has become increasingly evident that overfishing of a resource, coupled with an increase of pollution and other man-caused environmental changes, may be considered the major agents responsible for an actual decrease or eventual extinction of a fishery (McHugh, 1964). Such has been the case of at least one important shellfish resource in Raritan Bay, New Jersey.

During the oyster's relatively short economic history within the confines of Raritan Bay, it has declined from a species of major commercial importance to a nonentity. Of the two clam varieties endemic to the area — Soft Shelled Clam, _Mya arenaria_, and Northern Quahaug, _Mercenaria mercenaria_ the soft-shelled clam, although having declined considerably, has nevertheless managed to maintain a population in the western portion as well as the Sandy Hook section of the bay. Predictions relevant to the fate of the quahaug fishery are more difficult to form, due to the area-confining aspects pollution has had on the fishery. Until the below-described shellfish resource survey was completed, any estimates of the commercial shellfish resource in the whole of Raritan Bay were opinions based on conjecture.

From a historical standpoint, the shellfish resources of Raritan Bay have been adequately summarized on several occasions over past decades as indicated by Dr. Julius Nelson's (1909) records on oyster production; Cumming, Purdy, Ritter (1916); and Cumming (1917) exhaustive studies of pollution of growing areas. Cumming and his associates confined their studies to the effect of domestic waste on shellfish waters, while Dr. Nelson (1916), during the same period, investigated the effect of industrial pollution in the form of metallic copper upon the oyster itself. Within a few years, following Dr. Nelson's studies, the oyster industry in Raritan Bay became virtually extinct due to this predicted effect of metallic copper on the environment (Nelson 1916).

Between the time of these major contributions and the present, ecological studies were initiated to evaluate the relationships of pollution to marine animals. An earlier study by Udell (1951) was concerned with the effect of pollution on shellfish. Later, a combination biological-oceanographic study was conducted to determine the distribution and diversity of planktonic organisms, as well as nutrients, in conjunction with current patterns and related pollution (Patten, 1959; Jeffries, 1962).

Closely related to the sanitary quality of the waters of Raritan Bay is the related decrease in the availability of the shellfish resources. Over the span of 60 years, more and more shellfish grounds have been closed due to sewage pollution, resulting in a rather steady decline in the fishery. Finally, by 1961, almost 90 percent of the original grounds had become unavailable.

As a result of public demand in the early part of the century, oysters were accorded a much higher rank than any other shellfish in Raritan Bay. According to Cumming (1917), about 20,000 acres on the New York side of the bay contained oysters, 8,000 of which were under cultivation by private industry. New Jersey, in comparison, accounted for much less in total productivity. Cumming also reported that "flats and foreshores have many extensive hard clam and soft clam producing areas." Sandy Hook was the most noticeable of these as a continuous producer of soft clams. Shellfish growing and shipping in New Jersey during this period was asserted to be one of the most important industries in the state with the annual oyster catch alone valued at from two-to-four million dollars.

Post-World War II evaluations of the shellfish resources in Raritan Bay are few in number and these are confined to investigations conducted by Rutgers University biologists on particular sections of the bay, with emphasis equally divided between life history studies and population studies. New Jersey waters, therefore, have received the bulk of the attention on the two commercial species. The soft clam, *Mya arenaria*,received considerable attention in the vicinity of Sandy Hook (Durand, 1950; Aldrich, 1951; Shuster, 1952), while all of New Jersey commercial grounds were evaluated for density and distribution of the hard clam, Mercenaria mercenaria, (Haskin, 1962). Shellfish resource data are non-existent for the New York section of the bay, except for hearsay and assumptions based on past catch records.

Considerable attention was focused on Raritan Bay in 1961 as a result of "an epidemic of infectious hepatitis traceable to the consumption of raw clams from the Raritan Bay which led, on May 1, 1961, to the closing of the Bay to the harvesting of clams," (First Conference Session, 1961). As a result of this epidemic an intensive study of the environment and shellfish resources was initiated to evaluate the existing conditions in order to make formal recommendations for the best use of the waters in the future.

Due to the general lack of an adequate resource inventory in Raritan Bay, it was necessary to plan and execute a survey of the clam population in conjunction with a consideration of the sanitary quality and human health aspects of the shellfish resource. It was also desirable that the resulting data could be used to provide information pertinent to the commercial shellfish industry of Raritan Bay and to resource-management agencies of New York. It is believed that the survey data can be useful in connection with consideration of activities affecting the standing crop and in predicting recruitment and projected value of the fishery in the near future.

The above statements reflect the objectives and interests of the Northeast Shellfish Sanitation Research Center in the Shellfish resources of Raritan Bay. The study reported herein was conducted through cooperation with the Raritan Bay project of the Division of Water Supply and Pollution Control, Public Health Service, U.S. Department of Health, Education, and Welfare.

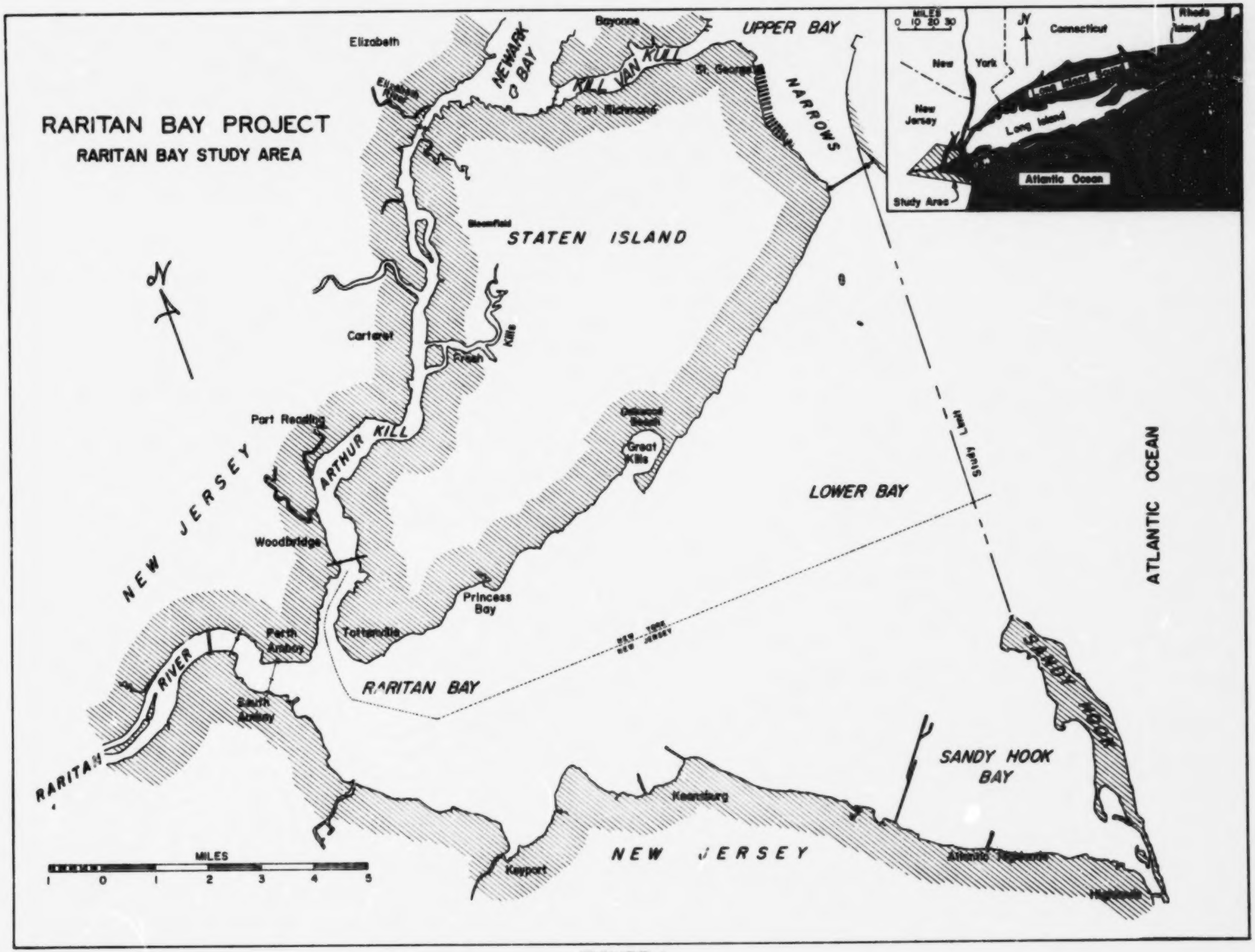
METHODS

The area under consideration, collectively referred to as Raritan Bay, is a triangular body of water with Lower Bay in the northeast sector, Raritan Bay located at the apex, and Sandy Hook Bay in the southeast sector. The bay extends inland for about ten miles between Staten Island, New York, to the northwest, and the east-west shoulder of New Jersey to the south. The eastern base of the enclosure is a ten-mile base opening to the Atlantic Ocean. The boundary between the two states passes approximately from east to west through the middle of the bay area to the western end (Figure 1).

The area of Raritan Bay which came under direct consideration during the survey was inside an imaginary line from the northern tip of Sandy Hook to the eastern-most point of Staten Island at the Narrows. The western limit was an imaginary line from Ward Point, Staten Island, southwest to the pier of the Jersey Central Power and Light Company in New Jersey (Figure 2). The northern and southern boundaries were the shorelines of Staten Island and New Jersey, respectively. Sampling was conducted to the mean low water mark and, through necessity, channel areas, restricted areas, and cable areas were excluded. The calculated sampling area totaled approximately 50,000 acres.

The assay techniques used for this survey were modification of those developed by the U.S. Fish and Wildlife Service, Clam investigations, in Narragansett Bay (1956). The variations occurred only in the methods of selecting sampling stations. Instead of using a sampling pattern based on a perfect grid with stations an equal distance apart, the stations were chosen by means of table of random numbers and applied to the numbered basic pattern. Economically, from a project cost standpoint and time considerations, this method was considered more feasible because of the large size of the area, which prohibited a small grid internal for a useful grid system, and because it removed any bias or tendency to select stations based on previous knowledge of shellfish distribution.

To locate the randomly distributed stations, it was first necessary to grid the area on the U.S. Coast & Geodetic Survey Chart #369 in 300-yard intervals oriented north and south and east and west along the lines of latitude and longitude. From the resulting 3026 squares, 535 were randomly selected to represent offshore stations, and 210 numbers to represent inshore stations. Thus, the population estimate is dependent upon these 745 stations. The results of this procedure indicate a rather evenly distributed sampling structure, as shown in Figure 2.


RARITAN BAY PROJECT
RARITAN BAY STUDY AREA

Elizabeth
Elizabeth River
NEWARK BAY
Bayonne
KILL VAN KULL
UPPER BAY
St. George
NARROWS
Port Richmond
Bloomfield
STATEN ISLAND
Carteret
Fresh Kills
Port Reading
ARTHUR KILL
Oakwood Beach
Great Kills
NEW JERSEY
Woodbridge
Princess Bay
Tottenville
Perth Amboy
RARITAN RIVER
South Amboy
RARITAN BAY
NEW YORK
NEW JERSEY
LOWER BAY
Study Limit
ATLANTIC OCEAN
SANDY HOOK
SANDY HOOK BAY
Keansburg
Keyport
NEW JERSEY
Atlantic Highlands
Highlands
MILES
1 0 1 2 3 4 5
MILES
0 10 20 30
Connecticut
Rhode Island
New York
New Jersey
Long Island
Long Island Sound
Atlantic Ocean
Study Area

FIGURE 1

GPO 955-949

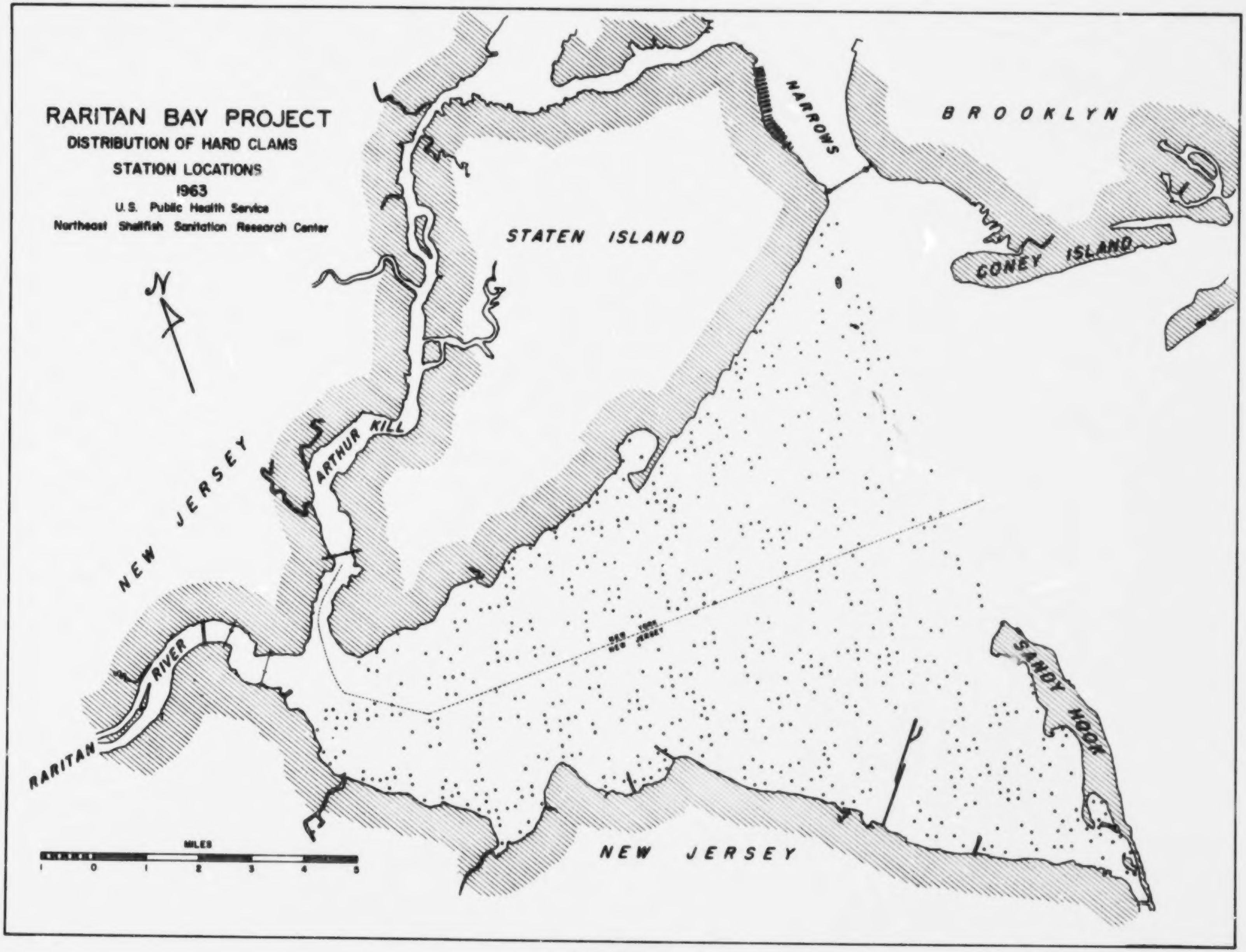

RARITAN BAY PROJECT
DISTRIBUTION OF HARD CLAMS
STATION LOCATIONS
1963
U.S. Public Health Service
Northeast Shellfish Sanitation Research Center
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
SANDY HOOK
NEW JERSEY
MILES
1 0 1 2 3 4 5

FIGURE 2

In the field, stations were located using shore bearings (sextant) and calculated running time of the vessel. While on station, a sample was obtained with a one-half yard construction-type, clam-shell bucket operated from a double-drum hydraulic winch aboard the U.S. Public Health Service R/V B. W. BROWN. The bucket covers a surface area of approximately five square feet and digs to a maximum depth of 18 inches. Experience indicated that the bucket sampled satisfactorily in most types of bottom except rocks. The sediment, after being brought aboard and dumped into a sorting box, was washed through a ½-inch mesh screening with salt water from the vessel's deck pump. Areas too shallow for the research vessel, draft 5', were sampled from a skiff using 16-foot, 12-tooth tongs. The samples taken within the 6' contour were classified as the inshore survey. The baskets of the tongs were enclosed with ½-inch wire screening and the handles modified to allow only restricted expansion. Two "grabs" with these altered tongs roughly equaled one "grab" with the clam-shell bucket (U.S.F.W.S. 1956).

Log sheets were kept for each station; data were recorded for bottom type and for the number and size of all commercially important shellfish in the sample. Measurements were made using vernier calipers on the longest diameters (lengths) of both hard and soft clams and recorded in millimeters.

Density-distribution charts (Figures 3-6) were prepared to present diagrammatically a general picture of how the three size-groups of hard clams were arranged on the bottom: "sub-legals" —— 15 to 46 millimeters in length; "necks" —— 47 to 66 millimeters long; and "large" —— over 66 millimeters. The density-distribution patterns are shown by "iso-clam" contours based upon categories of the number of hard clams per square foot (0.0, 0.2-1.0, 1.2-2.0, 2.2-3.0, and over 3.0) at each sampling station.

The data were analyzed at the University of Rhode Island Computer Laboratory, utilizing programs written for the IBM 1620 Data Processing System. We gratefully acknowledge the assistance of Dr. Saul B. Saila, Director of the Computer Laboratory, and his associates.

Sampling in the above-described area began on 17 July 1963 and continued to 23 August 1963. A total of 745 stations were occupied during this period. The survey was conducted by Mr. Robert Campbell, Marine Research Biologist, assisted by Capt. Arthur W. Smith, and three summer assistants from the Raritan Bay Project.

RESULTS

DISTRIBUTION - Two sub-areas of the shellfish resource survey were established by use of the boundary line between New York and New Jersey running in a general east-west direction almost through the center of the bay. This boundary provides almost equal division of the water area —— the New York sector comprising half of Raritan Bay and practically all of Lower Bay, while New Jersey makes up half of Raritan Bay, all of Sandy Hook Bay and a small portion of the Lower Bay. Presentation of the survey results according to state waters permits application by the state agencies concerned with these matters.

The general hard clam distribution is well illustrated in the "all-sizes" chart (Figure 3) and the pattern is rather closely adhered to, but to a lesser degree, by charts for each size category (Figures 4,5,6). The most outstanding feature of the "all-sizes" chart is the more even distribution of hard clams north of the state boundary in contrast to the "spotty" concentrations south of the line. The same holds true with respect to the distribution of heavier concentrations. The New York sector of Raritan Bay is, by far, more widely covered with commercial-size hard clams than its southern counterpart. "Sub-legals", however, are almost equally divided and contribute in a very minor degree to the overall pattern of total distribution. The general distribution patterns, particularly those for "sub-legals," are noticeably irregular and may be interpreted as being directly related to setting intensity and other factors. The observed distribution pattern "may be influenced by current patterns, bottom sediments, or general hydrographic conditions"(U.S.F.W.S. 1956).

A previous resource survey in New Jersey (Haskin, 1962), although using different equipment and techniques, shows close similarity in total hard clam distribution. The only difference between the two surveys is the "spottiness" of hard clams revealed by the recent assay compared with the relatively large areas of evenly distributed individuals in the former. This variability in assay may be attributed to the sampling technique, this method being one of random sampling where the tendency to locate stations based on previous knowledge is reserved.

DENSITY - The observed density of Mercenaria mercenaria differed greatly on the two sides of the bay. Thus, an independent estimate was made for both the New Jersey and New York sides of Raritan Bay. It was assumed, however, that the sampling distribution of the population was similar in each of the two bay areas.

An IBM 1620 computer program was used to test the fit of the observed frequency distribution to the negative binomial distribution. Past experience in a Narragansett Bay hard clam survey suggested fitting the negative binomial rather than some other sampling distribution. The following table (I) gives the chi-square values for the -5% and -95% levels of significance, and those calculated for the various sub-classes, testing the goodness of fit of the negative binomial.

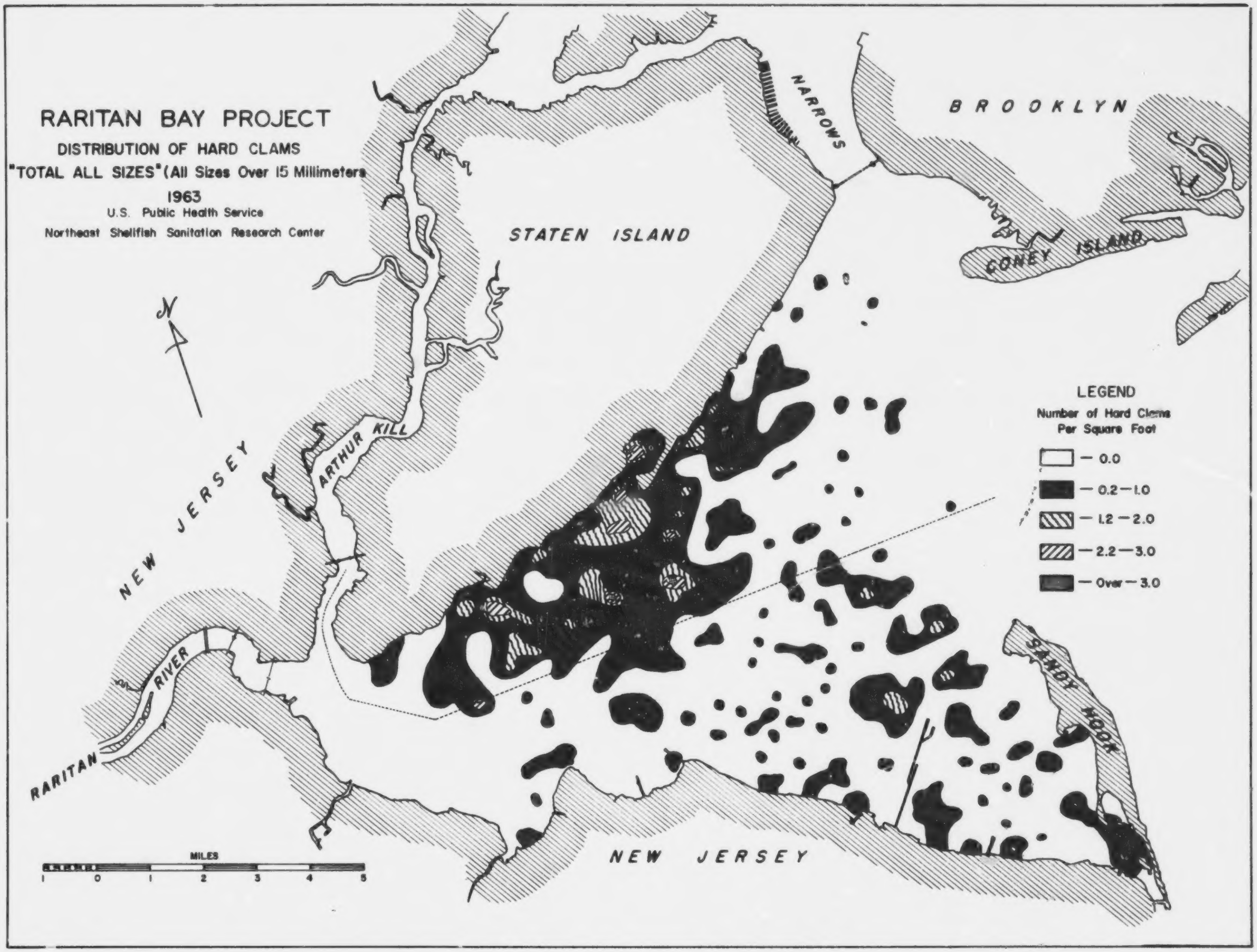
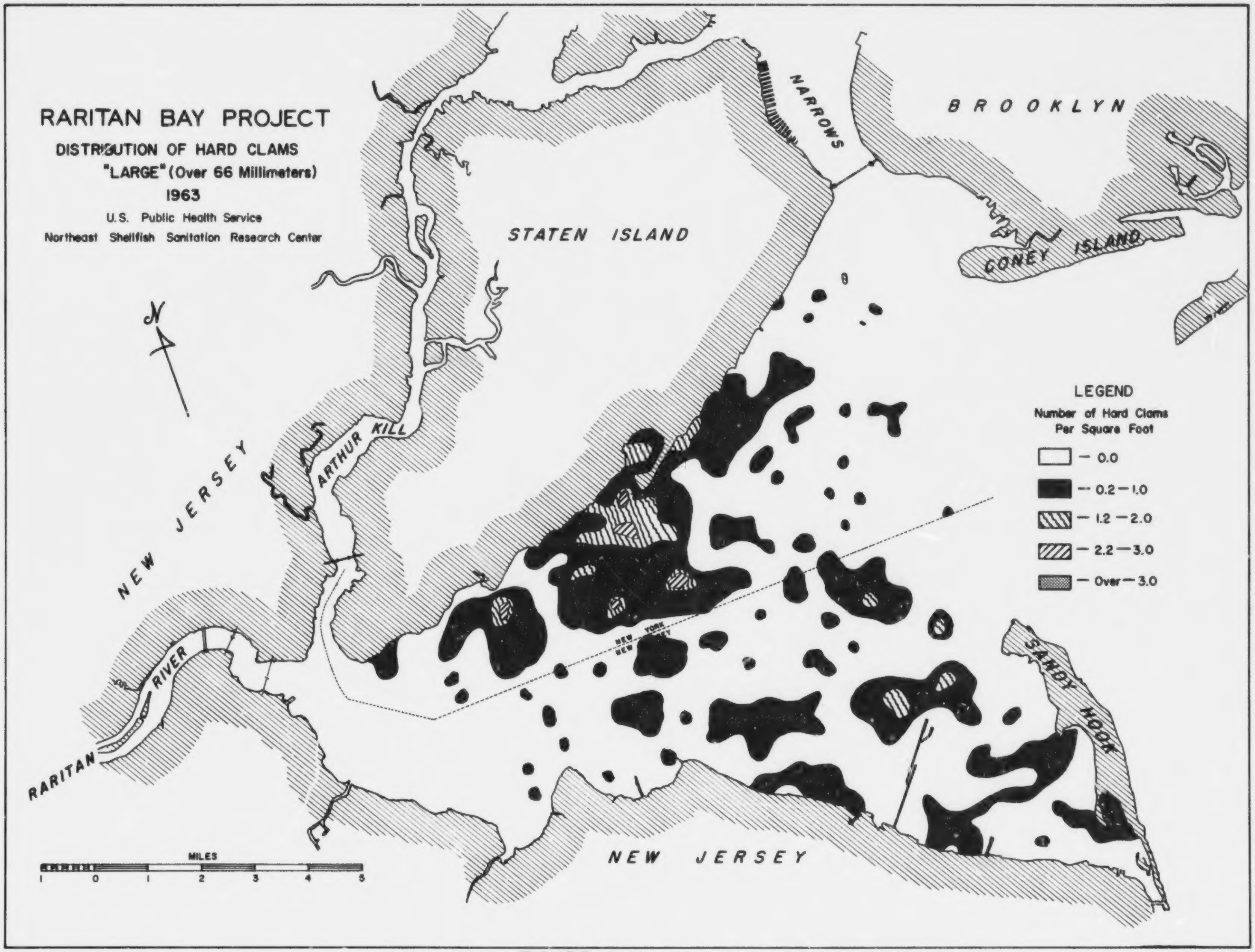

RARITAN BAY PROJECT
DISTRIBUTION OF HARD CLAMS
"TOTAL ALL SIZES" (All Sizes Over 15 Millimeters
1963
U.S. Public Health Service
Northeast Shellfish Sanitation Research Center
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW JERSEY
SANDY HOOK
LEGEND
Number of Hard Clams Per Square Foot
☐ — 0.0
■ — 0.2—1.0
▨ — 1.2—2.0
▨ — 2.2—3.0
■ — Over—3.0
MILES
1 0 1 2 3 4 5

FIGURE 3

GPO 956-592



RARITAN BAY PROJECT

DISTRIBUTION OF HARD CLAMS
"LARGE" (Over 66 Millimeters)
1963

U.S. Public Health Service
Northeast Shellfish Sanitation Research Center

STATEN ISLAND
BROOKLYN
NARROWS
CONEY ISLAND
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
SANDY HOOK
NEW YORK
NEW JERSEY
NEW JERSEY
N
LEGEND
Number of Hard Clams Per Square Foot
□ — 0.0
■ — 0.2 — 1.0
▧ — 1.2 — 2.0
▨ — 2.2 — 3.0
▩ — Over — 3.0
MILES
1 0 1 2 3 4 5

FIGURE 4

GPO 956-592

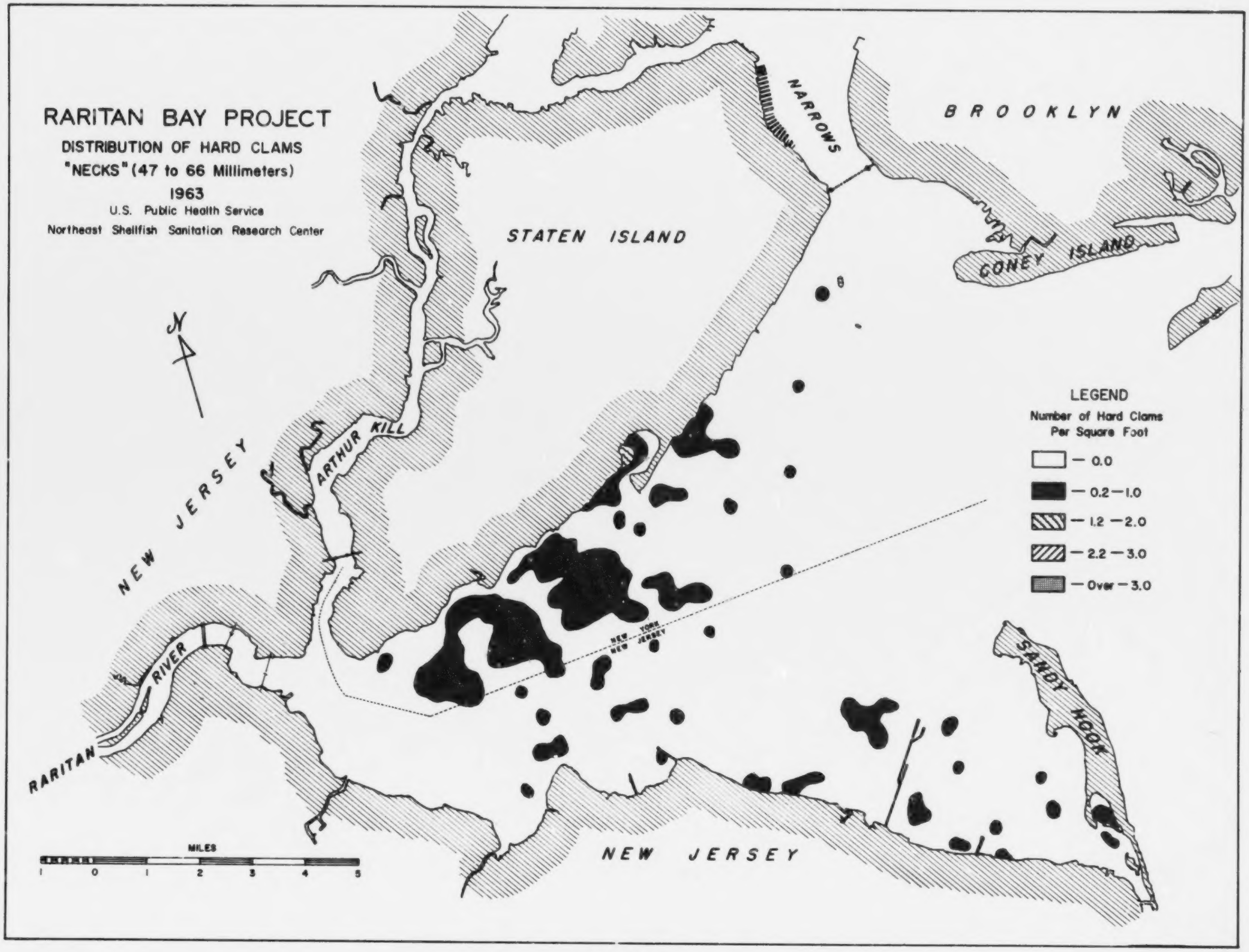

RARITAN BAY PROJECT
DISTRIBUTION OF HARD CLAMS
"NECKS" (47 to 66 Millimeters)
1963
U.S. Public Health Service
Northeast Shellfish Sanitation Research Center
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
SANDY HOOK
NEW JERSEY
LEGEND
Number of Hard Clams Per Square Foot
☐ — 0.0
■ — 0.2—1.0
▨ — 1.2 —2.0
▨ — 2.2 — 3.0
▩ — Over — 3.0
MILES
1 0 1 2 3 4 5

FIGURE 5

GPO 956-592

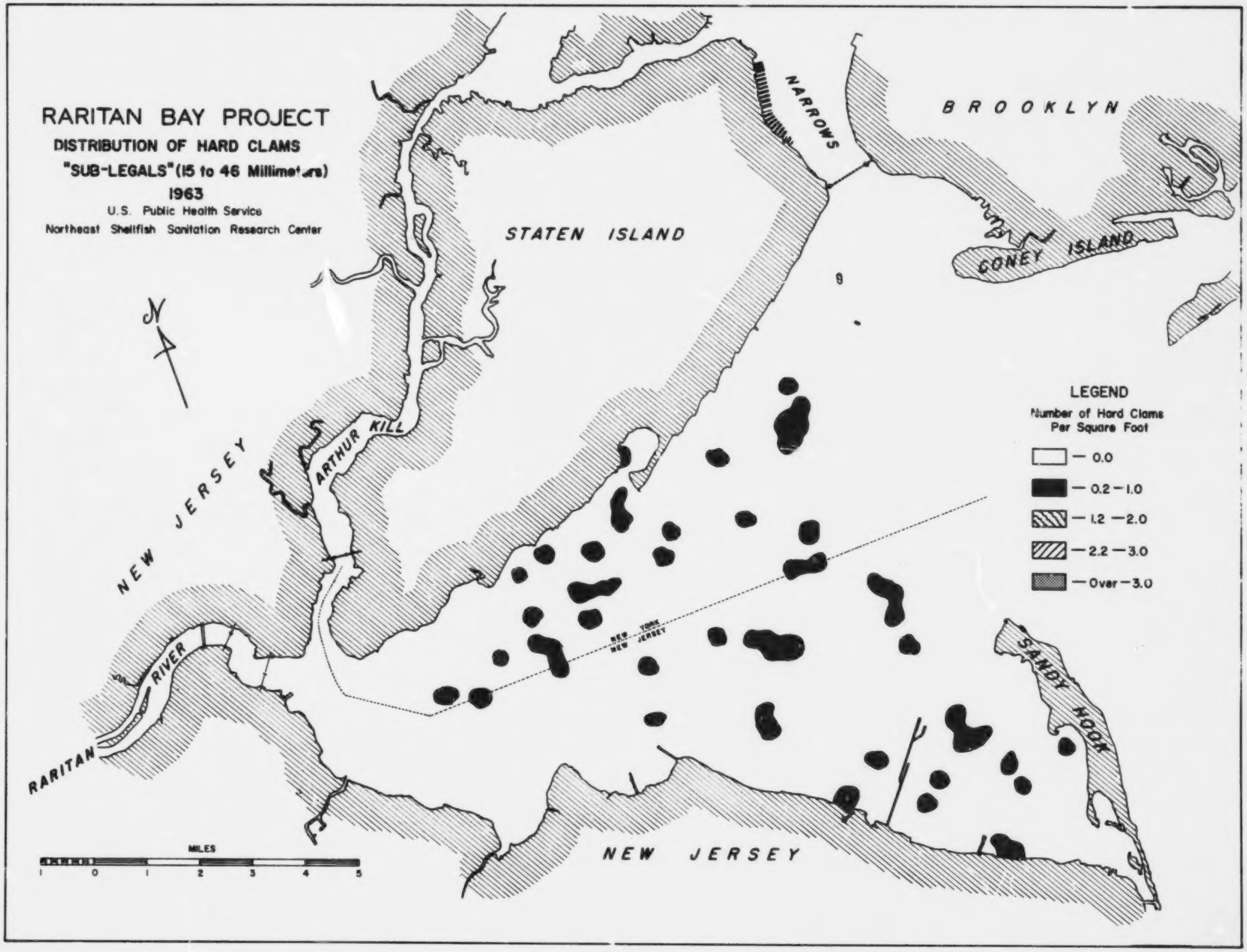

RARITAN BAY PROJECT
DISTRIBUTION OF HARD CLAMS
"SUB-LEGALS" (15 to 46 Millimeters)
1963
U.S. Public Health Service
Northeast Shellfish Sanitation Research Center
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
SANDY HOOK
NEW JERSEY
LEGEND
Number of Hard Clams Per Square Foot
— 0.0
— 0.2 — 1.0
— 1.2 — 2.0
— 2.2 — 3.0
— Over — 3.0
MILES
1 0 1 2 3 4 5

FIGURE 6

GPO 956-592

TABLE I

	Chi-x^2	Degrees of Freedom	-5%	-95%
New York:				
All sizes	11.82013	9	16.9	3.33
Large	3.24130	6	12.6	1.64
Necks	4.90236	2	5.99	.103
New Jersey:				
All sizes	1.74016	4	9.49	.711

It is clear from the table that the -5% value is not exceeded in any instance, and that a relatively good fit is provided by the negative binomial to the observed distribution. Conventional analysis of observations distributed in a manner such as that indicated by the quahaug is possible only after a suitable mathematical transformation. To this end the inverse hyperbolic sine transformation (Beale, 1954) was used. The means, variances and standard errors of estimate were computed from the transformed data. These values were then re-transformed for use in the estimates according to the method suggested by Quenouille, 1950. The confidence limits (where appropriate) were computed and the population estimates were made with respect to the bay and station areas provided by the sampling.

The abundance of hard clams is a reflection of the natural variability of distribution found in the northern and southern sections of Raritan Bay. As would be expected from observing the density-distribution patterns of the "all-sizes" category, the New York area proves to be more heavily populated, as indicated by an average density of 1.05 individuals per square foot compared to 0.47 individuals per square foot for New Jersey. From the standpoint of commercially important shellfish, New York possesses a 3:1 ratio for the "large"-size group compared with the "necks", whereas, New Jersey contains a more equal concentration between the two. The "sub-legal" group is the least abundant of the three divisions throughout the entire area and numerical values were not computed since the low frequency of occurrence of this group did not permit application of the statistical methods employed for other groups.

Total population estimates for each area were calculated only for the commercially important shellfish for which conversion factors are available. In the case of the "large" size hard clam a factor of 250 individuals per bushel was used, whereas a factor of 850 was used for the "neck" size category.

Establishing the value of the standing crop of any area, in the form of bushels per acre, is subject to error because of the size range of the individuals encountered and the inaccuracy of estimating the total area involved.

When interpreting the population size, using the above conversion factors, the ratio with respect to bushels are more pronounced. The differences in number of bushels becomes greater and is, in reality, a more comprehensive picture of the standing crop value of the resource. New York, in the case of "large" size hard clams, has almost triple the quantity New Jersey has, but only about equal quantities of "neck" size clams. The comparative resource values are contained in Table II.

TABLE II

STANDING CROP ESTIMATES FOR HARD SHALL CLAMS IN RARITEN BAY

	New York	(Confidence Limits)
Bushels of "Necks"	291,200	± 212,702
Bushels of "Large"	3,153,000	± 454,818
Total Bushels	3,444,200	± 667,520

	New Jersey	(Confidence Limits)
Bushels of "Necks"	353,000)	Point estimates
Bushels of "Large"	1,040,000)	
Total Bushels	1,393,000)	

SOFT CLAM DENSITY-DISTRIBUTION - The soft clam, *Mya arenaris*, proved to be more widely dispersed in the western sector of the bay than was expected. Patches of sub-legal animals were also apparent in Sandy Hook Bay, as well as protected coves within Sandy Hook peninsula. The general distribution illustrated in Figure 7 suggests a rather evenly but widely scattered pattern of "sub-legal" size (<2") soft clams and appears quite surprising considering the depth of water involved. "Legal" size shellfish were less abundant and appeared more or less confined to specific locations; in most instances they were intermixed with large quantities of "sub-legal" animals. No attempt was made to assign a quantitative figure to the soft clam resource because of the ineffectiveness of the clam shell bucket and tongs to obtain an equally representative sample of soft clams in the extreme type bottoms encountered in the bay. The soft clam results, therefore, are somewhat biased toward the smaller sizes. It is of interest to note that samples from some areas contained from 1 to 284 animals, of which 90 percent or more were of the "sub-legal" category.

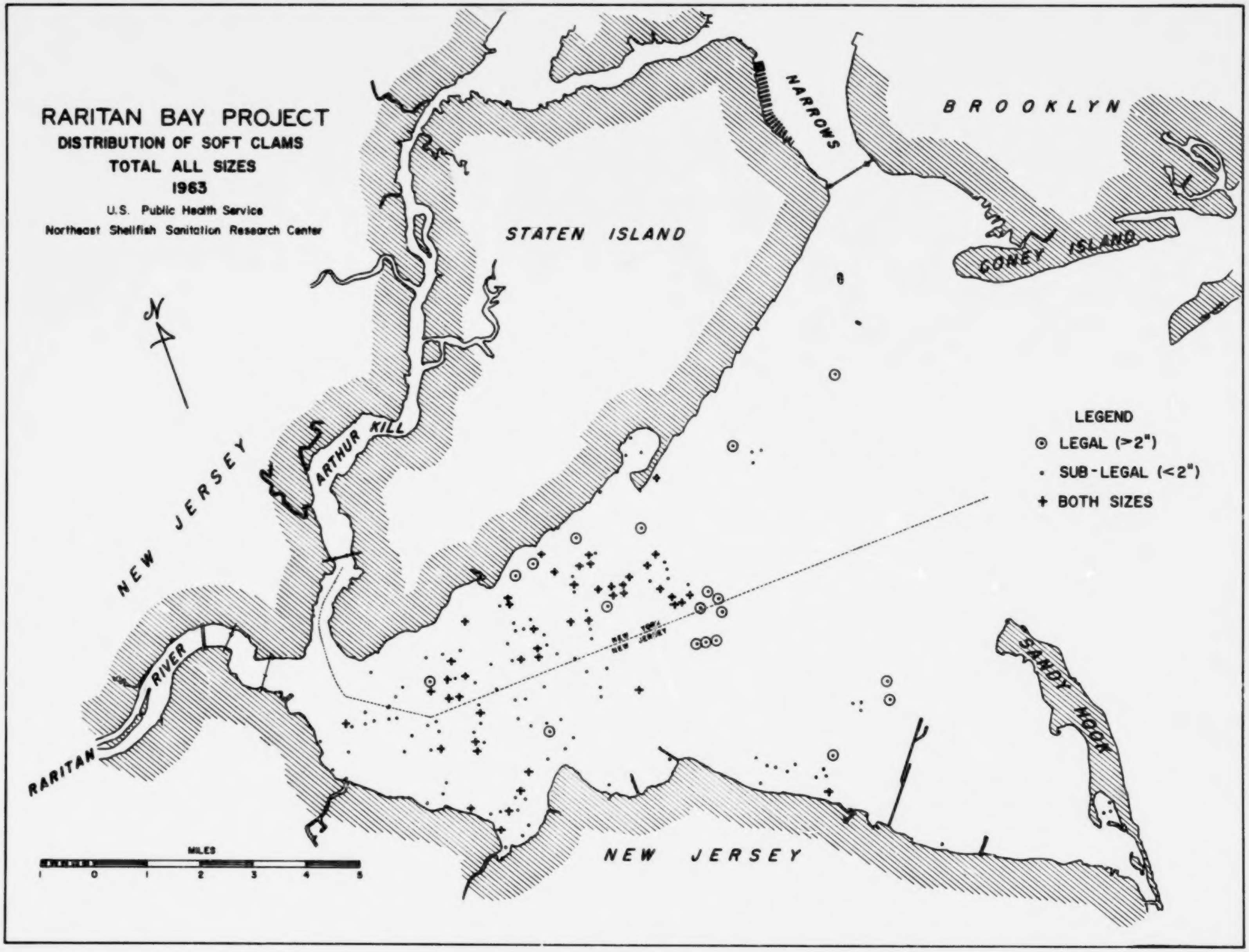

RARITAN BAY PROJECT
DISTRIBUTION OF SOFT CLAMS
TOTAL ALL SIZES
1963
U.S. Public Health Service
Northeast Shellfish Sanitation Research Center
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
SANDY HOOK
NEW JERSEY
LEGEND
⊙ LEGAL (>2")
· SUB-LEGAL (<2")
+ BOTH SIZES
MILES
1 0 1 2 3 4 5

FIGURE 7

GPO 956-592

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UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
59 Temple Place
Boston, Massachusetts 02111

October 28, 1964

Mr. Earl J. Anderson
Regional Program Director
Public Health Service
42 Broadway
New York City, New York

Dear Mr. Anderson:

This report provides information on the fish and wildlife resources of the Raritan, Lower New York, and Sandy Hook Bays, located in Richmond County, New York, and Monmouth and Middlesex Counties, New Jersey, as related to your comprehensive water quality studies in this area. It has been prepared in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-666 inc.), in cooperation with the New Jersey Divisions of Fish and Game and Shell Fisheries and the New York State Conservation Department. Those agencies concur in the report as indicated in their letters of October 9, October 10, and October 19, 1964, respectively.

We understand that your studies are directed toward developing maximum benefits from a program to abate domestic, municipal, and industrial pollution in the project area. This report evaluates the present fish and wildlife resources and presents data on the effect of improved water quality on these resources.

The tidal flats, channels, and wetland areas of the Raritan Bay area offer a variety of extremely productive habitats for waterfowl, finfish, and shellfish. The project area includes Raritan Bay, Sandy Hook Bay, and that part of Lower New York Bay west of a line from the tip of Sandy Hook to the eastern tip of Staten Island. It is characterized by a rich biological productivity and is located in close proximity to the most concentrated urban and industrial complex in the United States. The chemical industry concentration is the largest in the country. The central area, primarily in Lower New York Bay, averages around 21-feet deep. The project area is bisected by one of the most heavily traveled shipping channels in the world.

Commercial Shellfishery

The commercial shellfish resources presently consist of hard clams, soft clams, and blue crabs. The history of the shellfish resource in the project area indicates that the harvest reached a peak in the late 1800s and maintained that level until about 1945 when it began a gradual decline to reach the present low level. Oyster production was once a major activity in this area. At present, due to the destruction of seed beds, increased salinity due to channel dredging, and the increased pollution load, the oyster has disappeared.

Hard Clams

Hard clams are the most important species from the commercial standpoint. About 50 percent of the project area is considered to be commercial hard clam habitat. Due to the present pollution conditions, only a portion of Sandy Hook Bay is open to commercial clamming.

Many factors influence the distribution of the hard-clam resources. Of the four bottom types (1) sand, (2) sand and mud (sticky), (3) shell or gravel bed, and (4) black mud, only the latter is not always considered productive for shellfish. Other factors, such as sunlight, which directly influences microscopic plant production, water temperature, and water evaporation; rainfall, which affects salinity and water exchange; winds, which affect the movement of the water within the bay and between the bay and its tributaries, all have an influence on the distribution of hard-clam resources in the bay.

The history of the commercial fishery for hard clams in the Raritan Bay project area is one of steadily decreasing harvests as the spread of pollution closed the hard-clam beds to exploitation. No specific data are available to indicate the total harvests in the early years. Limited data indicate that as recently as 1958, harvests of hard clams worth about $500,000 annually were being taken. At the present time the limited area open to clamming in Sandy Hook Bay provides an annual harvest of about $40,000.

There are no present plans to increase this harvest. Methods of chemical purification have not been worked out for the hard clam, and data are not available at the present time that would indicate any procedure would be developed in the near future. Plans for transplanting of hard clams are being developed by the State of New York as part of their present program of depletion of restricted areas. It is estimated that such a program will include clams valued at $750,000 annually which will eventually be marketed from the beds on which they have cleansed themselves.

A recent study by the U.S. Public Health Service revealed a standing population of 3,444,000 bushels in the New York section of the project area and 1,393,000 bushels in New Jersey. Based on a current average price of $7.00 per bushel, the standing crop is presently worth over $34,000,000. Under optimum water quality conditions for this resource the potential harvest would be about 550,000 bushels annually with a value of about $3,850,000. While it is obvious that water quality conditions are such that these shellfish cannot be released for harvesting at the present time, at least half of this quantity could be absorbed by the market now and the entire amount utilized annually with proper promotion and market development.

Soft Clams

In the past, soft clams were taken commercially along the New Jersey coast from Conaskonk Point to the northern tip of Sandy Hook. In New York the production area included the entire south shore of Staten Island. This species is found throughout the project area except in the extremely deep waters.

The history of the soft clam follows that of the hard clam is that deteriorating habitat conditions resulted in a decline of the fishery. The latest commercial harvest data reveal that in 1948 about 175,000 bushels of soft clams valued at over $600,000 were taken. At the present time there is no significant commercial harvest.

Under optimum conditions the soft-clam beds can produce a sustained average annual yield of 300 bushels per acre of habitat. It is estimated that about 40,000 acres of the project area are soft-clam habitat. This analysis indicates a potential commercial value of about $18,000,000 annually, or about seven times the value of current landings of soft clams for the entire Atlantic seaboard.

It is assumed that before any effort is made to market soft-clam products from this area, there must be complete agreement on the part of the U.S. Public Health Service, the various State departments of health, and the State conservation departments that the soft clam product meets the requirements of quality and wholesomeness.

Although soft-clam production in this area would likely have a naturally slow development, increase in soft-clam production would have to be geared to a program of market development and promotion to avoid the creation of soft-clam marketing problems in other areas. It is considered that the development of new markets is possible inasmuch as new preservation techniques are being developed for fishing products and a marketing potential of inland distribution is available.

Blue Crabs

Formerly, the entire project area was considered blue crab habitat. At the present time the outer portions of the project area are still in good condition but the beach erosion and navigation improvements in the upper portions have caused deterioration of the habitat.

The commercial crab fishery in the project area is largely a winter dredge fishery. During spring, summer, and fall, the crab population spreads out to the shallow waters. During the period November to March the crabs concentrate in the deeper waters and hiberrate in the muddy bottom. At this time they are taken by the large dredge boats and by the smaller one-man garvey dredge boats.

The commercial blue crab fishery is subject to violent fluctuations throughout its range. While there are no specific data for blue crab harvests in the early days of the fishery in the project area, data covering adjoining areas indicate that the blue crab harvests are continuing these fluctuations. The 1960 blue crab harvest in New Jersey, for instance, was the second largest on record. In view of this it is difficult to connect any effect on the commercial blue crab fishery with the water quality conditions in the project area.

Commercial Finfishery

The commercial finfishery exhibits the same history in the Raritan Bay project area as the commercial shellfishery. Peak catches, with an estimated value of $2,000,000 were reported about the turn of the century and, on the average, have declined to the present time. Certain finfish species, such as the scup and black sea bass, are now taken in greater quantity than in the past, but this is believed to be due to the smaller supply of more favored food fishes and the resultant change in fish harvests.

In the recent past the method of harvesting commercial finfish has changed in the project area. Formerly, the area supported an abundance of finfish that could be taken in commercial quantities by a single operation in a small boat. Most of these fishermen worked on a part-time basis. As the supply of these fish diminished due to destruction of habitat, pollution, and overfishing, this type of operation became uneconomical. The change to large vessels with crews began about 1945 and is continuing to the present. Table 1 reflects the number of commercial fishermen, vessels, boats, and major gear as recorded in 1950 and 1960, the latest date for which these data are available.

Table 1
Commercial Fisherman Vessels, Boats, and Major Gear
Raritan Bay Project Area

	1950	1960
Fishermen		
On vessels	297	459
Boats and shore		
Regular	204	209
Casual	463	227
Total	964	895
Motor vessels	32	83
Motor boats	345	311
Other boats	65	23
Pound nets	76	68
Purse seines	11	13
Otter trawls	2	45
Gill nets	94	14
Clam dredges	38	94
Crab dredges	38	23

The present commercial finfish harvest in the project area is estimated to be about $200,000. This includes those fish actually taken in the project area and those caught outside the project area, but are dependent on the inshore bays for part of their life cycle. The most valuable fish is the porgy followed in order by the Atlantic menhaden, American shad, whiting, bluefish, black sea bass, summer flounder, herring, eels, mackerel, striped bass, winter flounder, and butterfish. Other species are taken from time to time but are not considered significant in the commercial catch.

It is expected that with the trend to larger boats and more efficient gear the catch would increase over the long term trend to about $300,000 under present plans and programs to improve water quality conditions. Under optimum conditions of water quality and assuming that overfishing and physical destruction of habitat will not occur, it is estimated that the potential commercial finfishery would approximate $400,000 in annual value.

Marine Sport Fishery

Due to its proximity to the New York Metropolitan area, the sport fishing use in the project area is high. Sport fishing activity begins as soon as the weather breaks in March, starting with the winter flounder. In succession, striped bass, tautog, porgy, and summer flounder enter the fishery. By midsummer the porgy and summer flounder dominate the catch. Among other fish caught are: kingfish, black sea bass, weakfish, American shad, and northern puffer, which recently has been discovered to be quite a delicacy. Early in July, bluefish enter the bay and striped bass are again in evidence. By mid-September the summer flounder begin to drop out of the catch to be replaced by tautog and winter flounder. Fishing for bluefish and especially for striped bass continues on into autumn. These same species of fish form a part of the commercial fishery of the bay.

The number of pleasure boats which are berthed in the New Jersey section of the project area totals about 8,000. There are about 3,000 inboard and 5,000 outboard and sailboats. The New York section has a total of about 1,200, of which 400 are inboard and 800 are outboard and sailboats. About two-thirds of these boats are used for marine sport fishing. Most of the large inboard boats go outside project area limits to fish for porgies, bluefish, and other species. The smaller boats are usually restricted to the bay area.

A recent sport fishing survey conducted by the New Jersey Division of Fish and Game indicated that there were about 330,000 fisherman-days use of the New Jersey section of the project area during 1963. This is an increase of 30 percent from the year 1953. The sport fishery in the New York section of the project area is confined mostly to shore fishing for striped bass and bluefish. The party boats which operate out of Great Kills Harbor generally go out of the project area to fish for porgies, bluefish, and other species. An estimated 25,000 fisherman-days were expended on this sport in 1963 in the New York section of the project area.

The total sport fishing use of the project area is about 355,000 fisherman-days. At $1.50 per fisherman-day the present annual value is about $530,000. Present pollution control programs will be beneficial in the future and will double present values. Under optimum water quality conditions it is estimated that fishing use would at least triple to a value of about $1,590,000. In large measure this would be due to the improved quality of the fish from the human use standpoint. At the present time, due to the noxious taste in the meat of the fish, it is reported that relatively few are eaten.

Recreational Shellfishery

Blue crabs, soft clams, and hard clams, in that order, provide some recreation activity in the project area. In prior years a trip to the bay in pursuit of these shellfish was a favorite sport of thousands of people. Most of these have shifted their operations to the unpolluted areas of Long Island and Barnegat Bay in New Jersey.

About 7,000 recreational clamming licenses were sold in New Jersey in 1964 and it is estimated that about 10 percent of these were used in the project area in the open unpolluted waters in Sandy Hook Bay. No license is required for the taking of blue crabs in either State. Since the crab is not as susceptible to the effects of pollution, it is taken along the shoreline except in those upstream areas that are usually too roily for successful crabbing. At the present time it is estimated that about 35,000 mandays are spent in recreational shellfishing. At an average value of $1.00 per recreation day, the present value would be about $35,000. It is not expected that this sport would increase significantly in the future under present conditions. However, under optimum water quality conditions throughout the entire project area, it is estimated that this activity would increase at least five times and have an annual recreational value of about $175,000.

Wildlife

Except for waterfowl, the Raritan Bay project area is not significantly important to wildlife. The principal value to waterfowl is as a resting and feeding area during migration periods. There is little nesting activity dependent on the bay waters, although in mild years a considerable number of ducks spend the winter in the area.

Present hunting use of the waterfowl resource is limited. About 1,000 acres of salt marsh border the bay and, except for the wetlands in Cheesequake State Park, it is under constant threat of development. It is estimated that about 1,000 man-days worth approximately $3,000, constitute the present waterfowl hunting value. Improvement in water quality conditions would improve waterfowl habitat by increasing the food supply of small fish and shellfish but would have little effect on hunting opportunity.

Summary

The Raritan Bay Project area was once a leading producer of commercial and sport fish and shellfish. Human activity in the interests of navigation, beach erosion control, hurricane protection, mosquito control, residential and industrial development have destroyed or altered adversely a considerable reach of the shoreline and the adjacent bay waters. Much of this adverse activity cannot be reversed to return the original conditions favorable to fish and shellfish. However, one of the major adverse factors is the effect of pollution on water quality. The increase in the pollution load in the waters of the project area has had a significant adverse effect on most of the fish and shellfish species. As a result, the productivity and the economic value of these resources are far below the potential productivity as is proven by past records of fish and shellfish harvest.

Present pollution control programs are increasing the value of these resources. This report also provides an optimum value of the resource if all sources of pollution are controlled. The question of defining values of a lesser degree of control is dependent to a degree on the type of control and the waste products to be controlled. The shellfish industry, for instance, could not be reinstated until the water quality conditions met the required 70 M.P.N. standard. This Service and the States of New York and New Jersey will be pleased to work with you and will attempt to provide data that may be required in the course of your study.

Sincerely yours,

s/Fred L. Jacobson
Acting Regional Director
Bureau of Sport Fisheries & Wildlife

s/John T. Gharrett
Regional Director
Bureau of Commercial Fisheries

RECREATIONAL BOATING IN RARITAN BAY

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SUMMARY

The Raritan Bay Project, Federal Water Pollution Control Administration, U.S. Department of the Interior, (formerly Public Health Service, U.S. Department of Health, Education, and Welfare) conducted a survey of recreational boating in Raritan Bay during July and August 1963. The purpose of this survey was to determine the magnitude of use, and the present and possible future economic values associated with recreational boating in Raritan Bay.

The survey found 63 marinas and 15 yacht clubs along the shores of the Raritan River, Raritan Bay and Arthur Kill. These facilities had a gross annual income of nearly $2,500,000 as a return on capital investment of approximately $10,500,000. The 5,480 boats surveyed represented a capital investment of nearly $22,000,000. With allowances for transit and trailed boats, recreational boating in 1963 provided an estimated 506,000 recreation days with a value of $760,000.

Future projections indicate a substantial increase in recreational boating. By 1985, the effects of population growth alone should increase this activity to over 1,000,000 recreation days, worth more than $1,500,000 annually.

INTRODUCTION

A survey of recreational boating was conducted during the period July 17 - August 10, 1963, as a part of the overall study of Raritan Bay by the Raritan Bay Project. The purpose of this survey was to determine the magnitude of use and the present and future economic values of recreational boating in the study waters.

According to Marion Clawson, "Recreation is a vital need in today's world. It is perhaps the greatest opportunity for self expression, for doing what one really wants to do, not what one is forced to do to earn a living. The very phenomena which have brought leisure and income have also brought serious tensions for every day life both working and living take place hurriedly, under crowded and often noisy conditions. Recreation under conditions of one's choosing is necessary to relieve these tensions. For many, the physical activity of outdoor recreation is vital in building and maintaining physical fitness and in discharging nervous energy."(1) Recreational boating fulfills all these requirements and is a family type of recreation enjoyed by all, regardless of age. Boating is also a natural adjunct to the enjoyment of such allied sports as swimming, fishing, skin-diving and water skiing.

The number of boats and outboard motors in use provides an index on the growth of recreational boating. The number of outboard motors in use in this country has risen rapidly from 1.8 million in 1947 to 6.4 million in 1963. Of the 1963 figure, nearly 900,000 motors, or 15% of the total in use, were located in the three states of New York, New Jersey and Connecticut. The number of boats in use has risen also, from 2.4 million in 1947 to 7.7 million in 1963(2).

SURVEY PROCEDURES AND RESULTS

Procedures: The survey was limited to recreational boating. Boats used for commercial fishing or for carrying passengers for profit, such as party and charter boats, were not included. The bodies of water included in the survey, as shown in Figure 1 are Sandy Hook, Raritan, and Lower New York Bays, the Raritan River, and Arthur Kill. The study area was divided into eight sections as shown in Figure 2. Areas A, B and C were located on the southern shore of Staten Island, New York; areas D, E and F the New Jersey shore of Raritan and Sandy Hook Bays; area G the shores of the Arthur Kill, and area H the navigable portion of the Raritan River.

Marinas, boat yards, and yacht clubs were located by contacting major oil companies supplying oil products in the area, by consulting phone directories, and by shoreline surveys. The United States Coast Guard was contacted for additional information. A total of 63 marinas and 15 yacht clubs were included in the survey. A staff visit was made to each of these facilities to obtain the needed information. The survey included only those activities directly related to recreational boating, such as rental of dockage space, repairs, and sales of equipment, fuel, bait, and tackle. Restaurants and boat yards specializing in major overhauling or construction were not included. In this survey, boats and yachts were classified and evaluated as follows:

Prams	- non-motorized	150
Sailboats	- non-motorized	1,500
Class A boats	- less than 16 feet	1,700
Class 1 boats	- 16 to less than 26 feet	3,000
Class 2 boats	- 26 to less than 40 feet	7,000
Class 3 boats	- 40 to not more than 65 feet	18,000
Boats over 65 feet	-	200,000

Results:

The results of the survey are summarized in Tables 1 through 4. Data were tabulated by individual areas, with sub-totals for both New York (Areas A, B and C) and New Jersey (Areas D through H). Although area G, the Arthur Kill, includes both New York and New Jersey, all of the activity noted during the survey was on the New Jersey shore. Therefore, this area was included in the New Jersey sub-totals. No values are shown for Area A, since this is a public beach area with no boating facilities.

Table 1 presents the number of boats counted during the survey, by area distribution and by size classification. A total of 5,480 boats were found, 4,577 of which were powered and subject to registration. These boats had an estimated total value of $22,000,000.

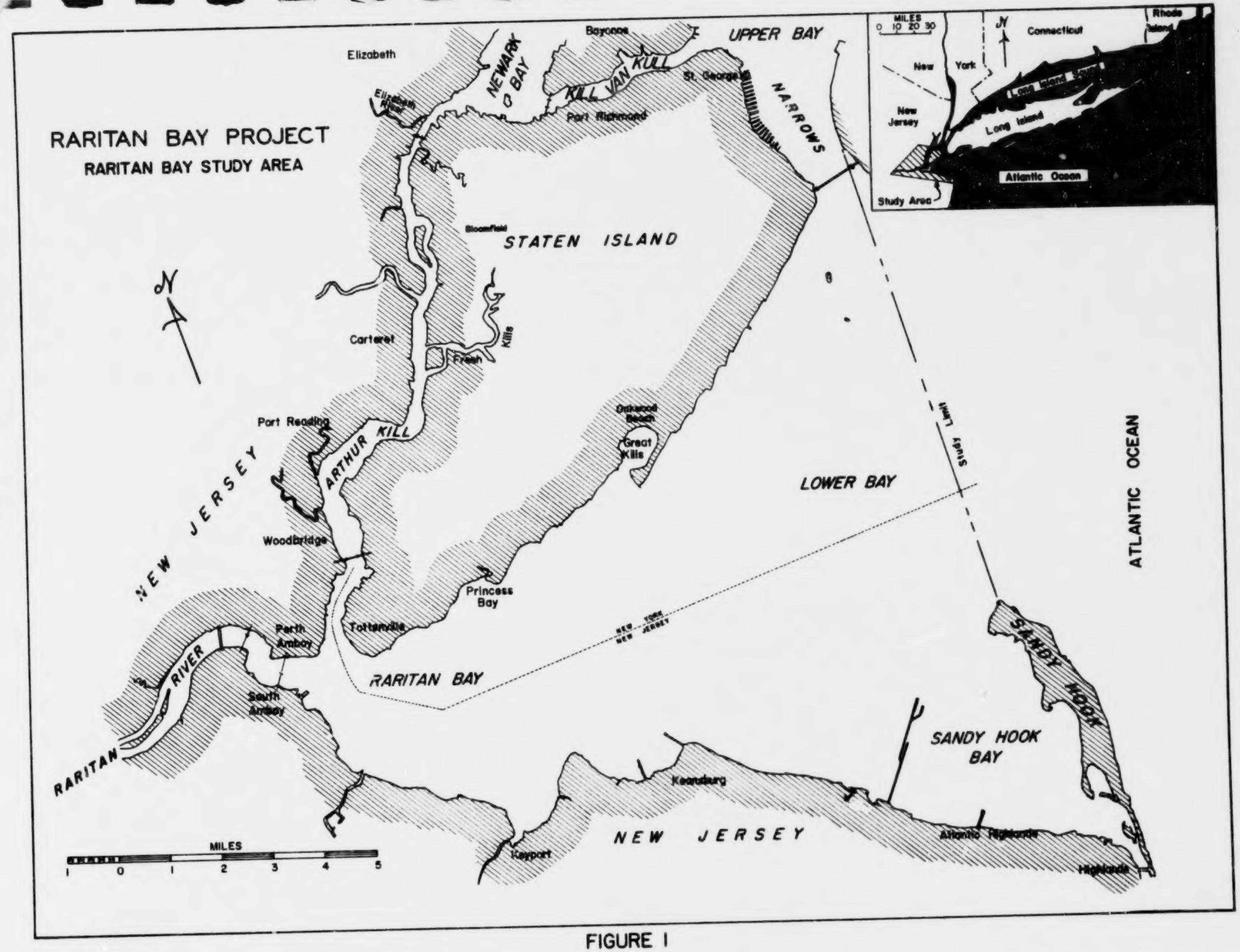
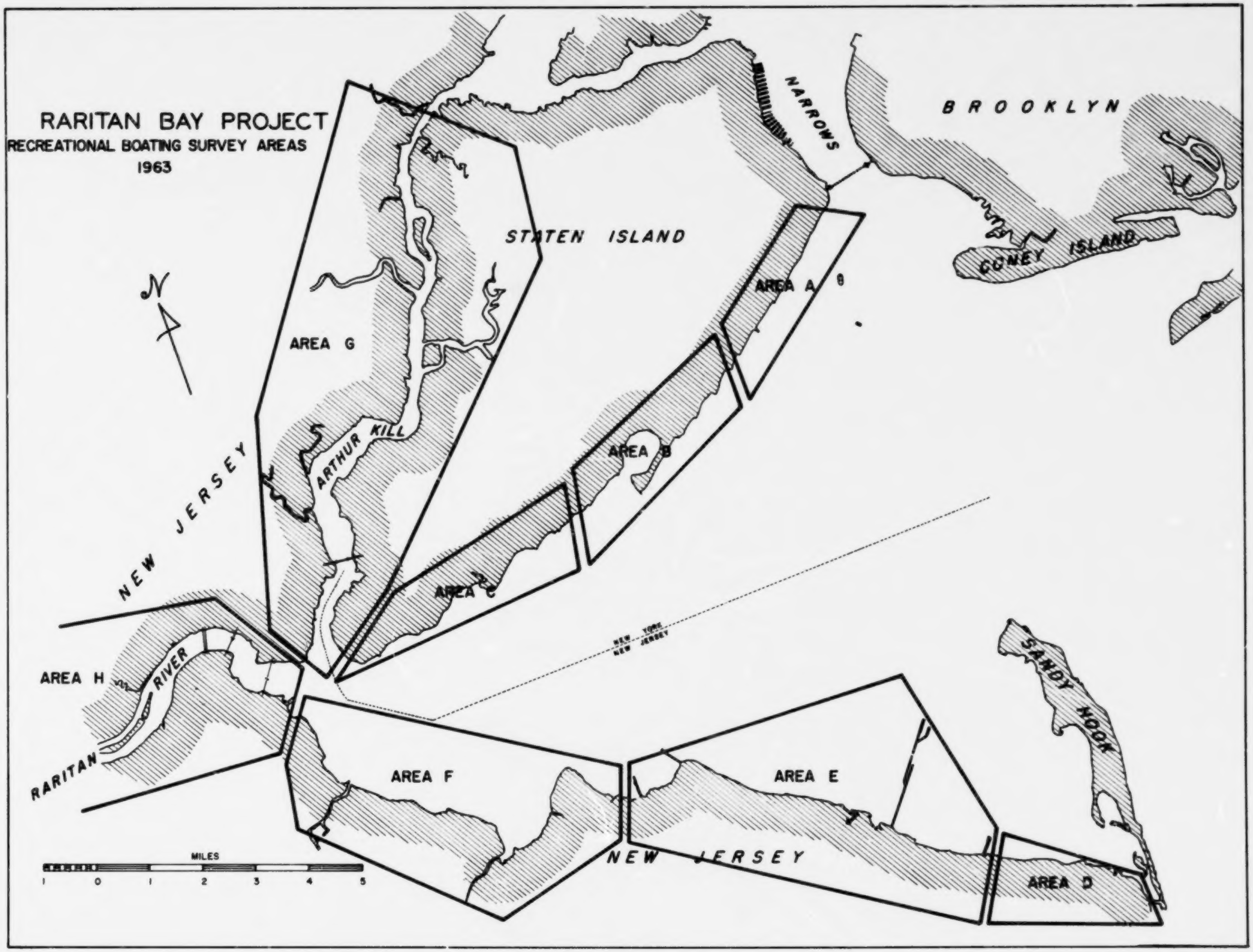

RARITAN BAY PROJECT
RARITAN BAY STUDY AREA
N
Elizabeth
Elizabeth River
NEWARK BAY
Bayonne
KILL VAN KULL
UPPER BAY
St. George
Port Richmond
NARROWS
Bloomfield
STATEN ISLAND
Carteret
Fresh Kills
Port Reading
ARTHUR KILL
NEW JERSEY
Woodbridge
Oakwood Beach
Great Kills
LOWER BAY
Study Limit
ATLANTIC OCEAN
Princess Bay
Tottenville
Perth Amboy
South Amboy
RARITAN RIVER
RARITAN BAY
NEW YORK
NEW JERSEY
SANDY HOOK
SANDY HOOK BAY
Keansburg
Keyport
Atlantic Highlands
Highlands
MILES
1 0 1 2 3 4 5
MILES
0 10 20 30
Connecticut
Rhode Island
New York
New Jersey
Long Island Sound
Long Island
Atlantic Ocean
Study Area

FIGURE I

GPO 955-949



RARITAN BAY PROJECT
RECREATIONAL BOATING SURVEY AREAS
1963

N
BROOKLYN
NARROWS
CONEY ISLAND
STATEN ISLAND
AREA A
AREA B
AREA C
AREA D
AREA E
AREA F
AREA G
AREA H
ARTHUR KILL
NEW JERSEY
NEW YORK
NEW JERSEY
RARITAN RIVER
SANDY HOOK
NEW JERSEY
MILES
1 0 1 2 3 4 5

FIGURE 2

GPO 956-592

TABLE I

RECREATIONAL BOATS IN RARITAN BAY

Area	Prams	Sailboats	Class A	Class 1	Class 2
A	-	-	-	-	-
B	38	2	157	140	22
C	53	109	283	504	249
Sub Total - NY	91	111	440	644	271
D	140	4	70	272	201
E	193	41	48	170	399
F	59	31	243	569	231
G	40	157	126	217	98
H	21	15	78	275	87
Sub Total - NJ	453	248	565	1503	1016
Total	544	359	1005	2147	1287

Area	Class 3	Over 65 ft.	Total	Rental Boats*	Value of Boats ($)
A	-	-	-	-	-
B	3	-	362	43	-
C	58	1	1257	33	-
Sub Total - NY	61	1	1619	76	6,055,150
D	9	-	696	130	-
E	28	4	883	136	-
F	6	-	1139	5	-
G	-	-	638	-	-
H	26	3	505	-	-
Sub Total - NJ	69	7	3861	271	15,663,450
Total	130	8	5480	347	21,718,600

*These boats are also included in their respective categories.

TABLE 2

RECREATIONAL BOAT USE IN RARITAN BAY - 1963

Class	No. of boats Surveyed	Days of Usage	Average Population	Man days Use
Non Powered	903	10	2	18,060
A	1,005	20	2	40,200
1	2,147	20	3	128,820
2	1,287	25	4	128,700
3	130	30	5	19,500
Over 65 feet	8	30	10	2,400
Total Surveyed	5,480			337,680
Estimated Transit and trailed vessel use				168,840
Total Estimated Use				506,520 Man days use

TABLE 3

ECONOMICS OF RECREATIONAL BOATING IN RARITAN BAY

Area		Gross Income ($)	Concessions[1/] ($)	Fuel ($)	Dockage ($)	Boat Rental ($)	Repairs[2/] ($)	Misc. ($)	Employment (Man-Yrs)	Salary ($)	Investment ($)
	A	-	-	-	-	-	-	-	-	-	-
	B	112,850	36,000	15,000	6,950	25,000	19,000	10,900	9	29,250	693,000
	C	584,000	148,640	35,000	195,750	20,000	157,750	26,860	49	218,400	2,219,000
Sub Total NY		696,850	184,640	50,000	202,700	45,000	176,750	37,760	58	247,650	2,912,000
	D	387,900	59,200	54,000	114,900	16,300	128,500	15,000	35	122,600	1,535,000
	E	353,000	56,000	64,000	115,000	27,000	2,000	89,000	20	70,700	2,300,000
	F	789,850	15,000	98,000	165,050	1,000	492,300	18,500	28	127,580	1,725,000
	G	107,200	26,000	4,000	28,200	-	12,000	37,000	14	40,000	1,422,000
	H	106,000	12,000	12,000	40,800	-	34,200	7,000	14	50,960	501,000
Sub Total NJ		1,743,950	168,200	232,000	463,950	44,300	669,000	166,500	111	411,840	7,483,000
TOTAL		2,440,800	352,840	282,000	666,650	89,300	845,750	204,260	169[3/]	659,490	10,395,000

[1/] Concessions include snack bars, bait and tackle shops.

[2/] Repairs include repairs of boats and equipment, sales and service.

[3/] Based on 117 full-time and 156 part-time (4 months per year) employees.

TABLE 4

DOCKAGE FACILITIES IN RARITAN BAY

Area		Berths		Moorings	
		Present	Anticipated	Present	Anticipated
	A	-	-	-	-
	B	322	336	44	116
	C	832	1269	337	449
Sub Total NY		1154	1605	381	565
	D	657	712	6	6
	E	788	2838	56	150
	F	1045	1745	107	352
	G	406	406	0	0
	H	247	927	96	500
Sub Total NJ		3143	6628	265	1108
TOTAL		4297	8233	646	1673

NOTE: Anticipated berths (or moorings) are the total number that are planned or proposed for future expansion by the marina owners.

The State of New Jersey Department of Conservation and Economic Development reported that about 90,000 boats were registered in that state in 1963. Of these, 36,000 were Class A, 43,000 Class 1, 10,000 Class 2, 1,000 Class 3 and five were over 65 feet in length. The Department estimated that 8,000 of these boats were in Raritan Bay and adjacent waters, including the Navesink and Shrewsbury Rivers.

The State of New York Conservation Department estimated that 350,000 boats were registered in New York State in 1963, and that approximately one-half of these were located in the Long Island New York City area. The Department's records showed 262,500 of these boats were Class A, with the remaining 87,500 in larger size categories.

In addition to the boats counted during the survey, other boats used the Raritan Bay waters during 1963, either as transient visitors from outside the survey area, or as trailed boats. It was estimated that vessel use in this category was approximately one-half that attributed to the boats surveyed. Table 2 indicates approximately 506,000 recreation days were involved in this phase of recreation in 1963. The Ad Hoc Water Resources Council has suggested a value of \$0.50 to \$1.50 per recreation day for general outdoor recreation(3). Assuming the upper value of \$1.50 per recreation day spent in recreational boating, the estimated value of this activity in 1963 was \$760,000.

The investment in real estate and improvements, and the gross income associated with recreational boating in Raritan Bay is presented in Table 3. The employment figures were based upon the total number of employees found in the survey, 273, of whom the 156 summer or part-time help were assumed to work 4 months per year. Recreational boating in 1963 provided a gross annual income to the area of \$2,440,000 on a capital investment of \$10,400,000.

A comparison of the gross annual income for recreational boating in Raritan Bay and the upper value of \$1.50 per general recreation day recommended by the Ad Hoc Water Resources Committee suggests the latter value is conservative. Based upon the observed gross annual income of \$2,440,000 for 506,000 recreational days, a closer value estimate would appear to be in the order of \$4.50 per recreational day spent in recreational boating.

Table 4 presents the existing number of boat berths and moorings, and the additional number anticipated by marina operators for expansion in the foreseeable future. These data show that the operators plan to more than double the existing facilities.

PROJECTIONS

Any projection of future growth of recreational boating in the study area must consider a number of factors. Certainly for this form of recreation to increase, water quality must be suitable for this use. Obnoxious odors, objectionable esthetic floating matter, and oil slicks would not tend to lure people to relaxation. Assuming suitable water quality is available, other essential growth factors are population, income, leisure and mobility.

The 1955 and 1960 census figures as well as projected populations made by the Metropolitan Regional Council for 1965, 1975 and 1985, for the United States, the New York Metropolitan Region, and the five counties bordering Raritan Bay are:

Population in Millions

	1955	1960	1965	1975	1985
United States	165	179	196	235	286
N.Y. Metrop. Region	15	16	18	21	24
Five Counties*	1.4	1.6	2.2	3.2	4.3

*Richmond County (Staten Island), New York; Middlesex, Monmouth, Somerset and Union Counties, New Jersey

A gradual population decrease is expected in New York City as a whole, with borough decreases in Manhattan, Brooklyn and the Bronx, stability in Queens, and an increase in Richmond (Staten Island).

Personal annual income in the United States in 1955 was $1,865 per capita and is expected to rise to $3,285 (both in 1955 dollars) by 1985. During the same period, personal annual income in the New York Metropolitan Region is expected to increase from $2,470 to $4,350.(1) As incomes and purchasing power increase, more money will be available for recreation.

Leisure time in this country will be greatly enhanced. It is anticipated that the present 40 hour work week will be reduced to about 32 hours by 1985. Such a reduction in work hours could result in a six and one-half hour day, a four day week, a two or three month paid vacation, or more likely some combination of these. At the same time there will be more leisure for the non-working portion of the population, due to earlier retirements and continued mechanization of household chores.(1)

People are expected to become even more mobile. Around 1900 the average American traveled only 500 miles annually. By 1955, largely because of the automobile, this figure rose 10 times to 5,000 miles per year. A further increase to 7,700 miles is expected by 1985. The potential for increased mobility in the New York Metropolitan Region in one important respect surpasses that for the nation, since this is the most mass-transit oriented metropolitan area in the country, with correspondingly fewer automobiles per capita. It is anticipated that passenger cars in the Region will increase from 3,900,000 to 8,600,000 between 1955 and 1985, a 120 percent rise in contrast to a population increase of 60 percent during the same period.(1) The increased mobility among the people in the Region, together with improved accessability with completion of the Verrazano-Narrows Bridge and other public works, will no doubt result in large increases in the recreational uses of the Raritan Bay by residents of the New York City Metropolitan Region.

Adequate water quality combined with the expected changes in population, income, leisure, and mobility will result in a great increase in recreational boating in Raritan Bay. Since the population in the five counties adjacent to the Bay will virtually double by 1985, it would appear that recreational days in boating should at least double. On this basis, the annual use in 1985 would amount to slightly over 1,000,000 recreation days, with an estimated annual value in excess of $1,500,000 using a conservative figure of $1.50 per recreation day, or $4,500,000 using the value of $4.50 per recreation day for this activity as noted during the survey.

FINDINGS AND CONCLUSIONS

1. A survey of recreational boating found 5,480 recreational boats, with an estimated capital value of $21,700,000, in the study area. In addition, an undetermined number of trailed and transient vessels used the bay waters.

2. In 1963, recreational boating in Raritan Bay provided approximately 506,000 recreation days, with an estimated annual value of $760,000.

3. Capital investment in the 63 marinas and 15 yacht clubs surveyed amounted to $10,440,000. Gross annual income to these facilities in 1963 was estimated at $2,440,000.

4. Planned or proposed moorings and berths will more than double the present capacity of the facilities surveyed in the near future.

5. Increases in population, income, leisure and mobility will result in a large growth of recreational boating in Raritan Bay. On the basis of population projections alone, it is estimated that in 1985 recreational boating will provide over 1,000,000 recreation days, valued at more than $1,500,000.

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RECREATIONAL BATHING - RARITAN BAY

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SUMMARY

The Raritan Bay Project, Federal Water Pollution Control Administration, U.S. Department of the Interior (formally Public Health Service, U.S. Department of Health, Education, and Welfare) conducted a survey of recreational bathing in Raritan Bay in 1963. The purpose of the study was to determine the present value of the bathing industry, and its potential for future growth.

The survey found 59 active bathing beaches in Raritan Bay and the Arthur Kill, 17 of which were municipally owned. The beaches had a land value of more than $23,000,000 with capital improvements in excess of $4,000,000.

Bather usage was light, with a density of only 10 persons per acre. Based upon $.50 per bather day, the industry had an annual value of $500,000 in 1963. Water quality was poor at many of the beaches, with geometric mean confirmed coliform MPN's at three sampling stations in excess of the maximum limits for bathing established by the New York City Department of Health.

Assuming adequate water quality is attained, the bathing industry in Raritan Bay has a future potential annual value, based upon $0.50 per bather day, of $12,000,000 a year.

INTRODUCTION

An important facet of water use is recreational activities, such as bathing. Hence, as part of its overall study of Raritan Bay, the Raritan Bay Project conducted a survey of recreational bathing during the summer of 1963.

The objectives of the bathing survey were to locate the beach areas; determine investments, bather usage and gross income to the industry; and to estimate the future growth of this water use.

The study included all municipally owned beaches, as well as privately owned beaches which were accessible to bathers other than the owners, within the Raritan Bay Project study area. This area, shown in Figure 1, includes the south shore of Staten Island, the shores of the Arthur Kill, and the New Jersey shore of Raritan Bay from the Raritan River to the Shrewsbury River.

SURVEY PROCEDURES AND RESULTS

Procedures: The beaches in the area were located by field reconnaissance. Each beach property was visited and the manager and/or owner contacted to obtain the needed information. The number of bathers in supervised beaches was obtained from records kept on the premises, while those in unsupervised beaches were estimated from inquiries in the area, and by counting the bathers at the time of the visits.

Values of beach land and improvements were determined from tax assessments. The land considered in the evaluation included both the beach proper and those adjacent areas used in conjuntion with the beach operation. Tax-exempt land was evaluated on the basis of values of representative properties as estimated by local tax boards, resulting in the following capital values:

Cottage	$2,000 each
Hotel	$1,000/room and $2,000/apt.
Pool	$25,000 each
Bathhouse	$2,000 each
Private House	$15,000 each
Picnic Shelter	$1,000 each
Refreshment Stand	$2,000 each
Club Building	$25,000 each
Restaurant	$25,000 each
Bar	$25,000 each

Information on the number of employees, salaries, and income from the industry was obtained from the management.

Data on the water quality in the bathing areas during the bathing season for 1963 were as determined by the Raritan Bay Project.

Results

The 59 active beaches surveyed are listed in Table 1 and located on Figure 2. Of the total number of beaches found, 42 were privately-owned and 17 were municipally-owned.

Table 2 presents the total area, frontage and value of the beaches surveyed. The total frontage is over 15 miles, virtually all located on the shores of Raritan Bay. The total beach land area was 1,450 acres. The value of land occupied by these beaches was $23,600,000 while improvements, which excluded the value of erosion control works by the U.S. Army Corps of Engineers and other public works, amounted to $4,200,000.

Table 3 indicates the bathing usage, gross income, employees and salaries for the 59 beaches. The total number of bathers was estimated at 1,070,000 during the summer of 1963, equivalent to a bather density of only 10 persons per acre per day for the 73 day season June 22-Sept.2 (Labor Day). The Ad Hoc Water Resources Council has suggested a value of $0.50 to $1.50 per general recreation day, to include bathing (1). Based on $0.50 per bather day, the value of bathing in Raritan Bay in 1963 was slightly in excess of $500,000.

The gross income at all the beaches and accompanying facilities surveyed totalled approximately $750,000 for the year ending September 2, 1963 (Labor Day). The income at the municipally owned beaches was augmented by municipal appropriations. The 65 year around and 464 summer employees received salaries totalling $748,000.

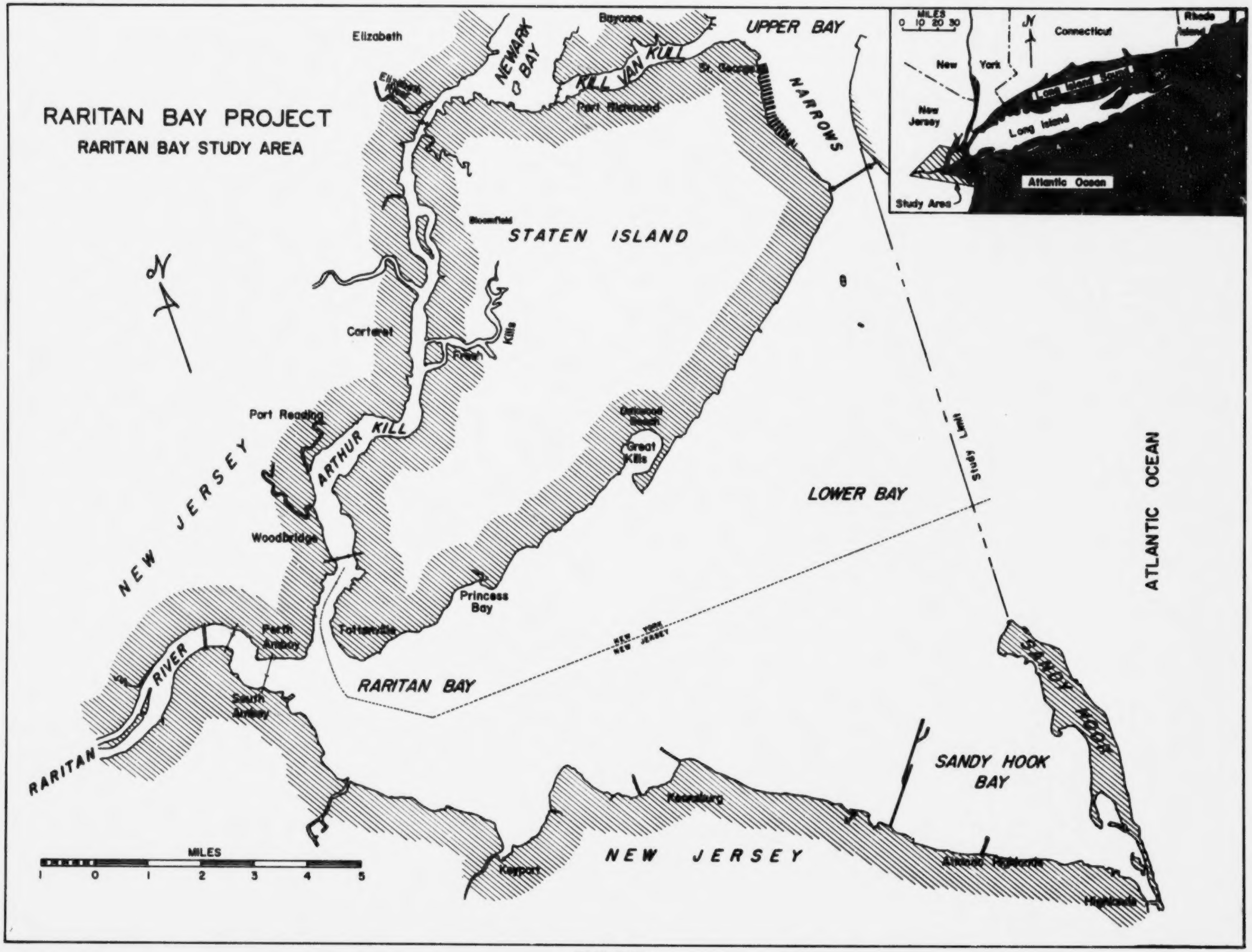
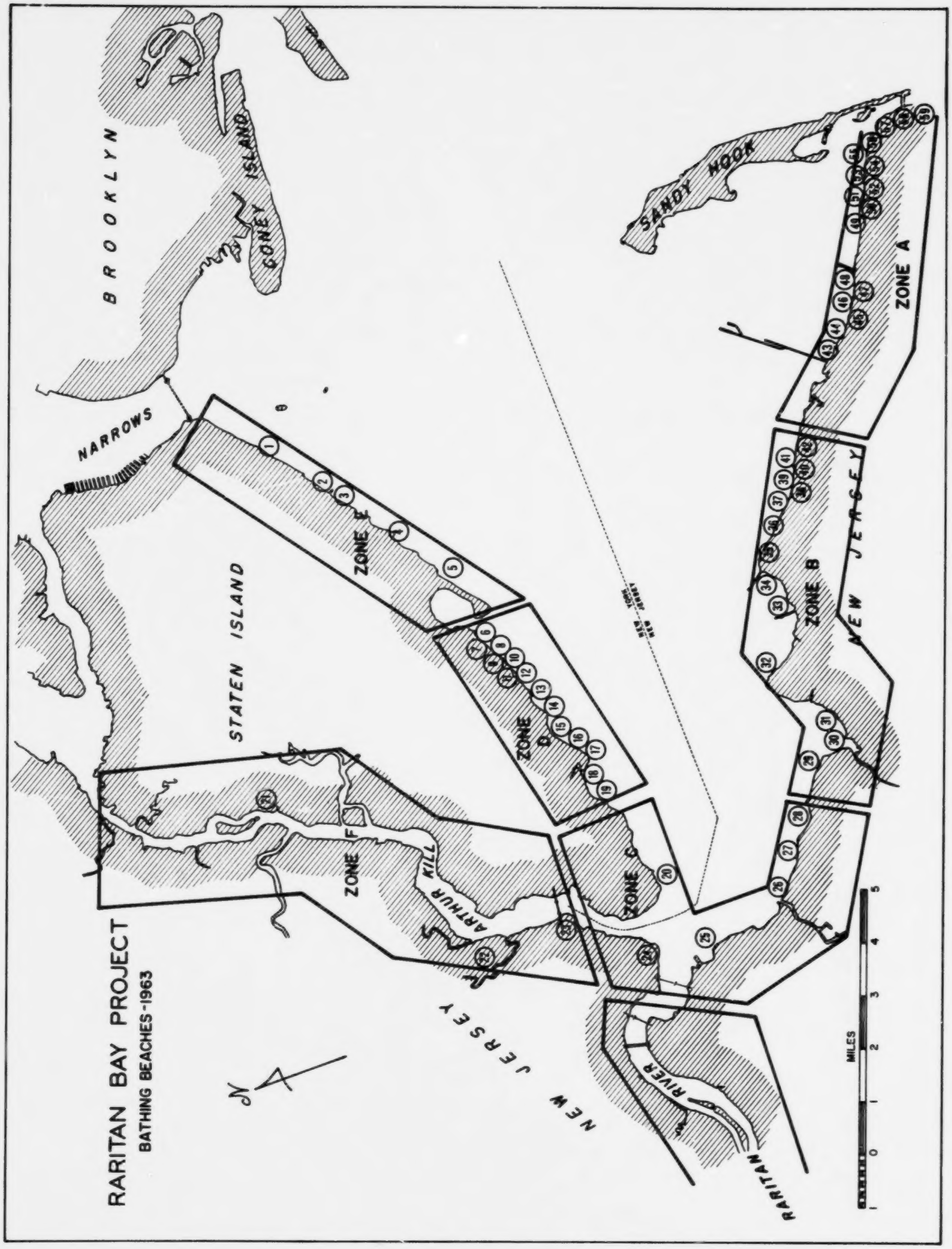

RARITAN BAY PROJECT
RARITAN BAY STUDY AREA
Elizabeth
Elizabeth River
NEWARK BAY
Bayonne
UPPER BAY
KILL VAN KULL
St. George
Port Richmond
NARROWS
STATEN ISLAND
Bloomfield
N
Carteret
Fresh Kills
Port Reading
ARTHUR KILL
NEW JERSEY
Woodbridge
Oakwood Beach
Great Kills
LOWER BAY
Study Limit
ATLANTIC OCEAN
Princess Bay
Tottenville
Perth Amboy
South Amboy
RARITAN RIVER
RARITAN BAY
NEW YORK
NEW JERSEY
SANDY HOOK
SANDY HOOK BAY
Keansburg
Keyport
NEW JERSEY
Atlantic Highlands
Highlands
MILES
1 0 1 2 3 4 5
MILES
0 10 20 30
N
Connecticut
Rhode Island
New York
New Jersey
Long Island Sound
Long Island
Atlantic Ocean
Study Area

FIGURE I

GPO 955-949



RARITAN BAY PROJECT
BATHING BEACHES-1963

BROOKLYN
CONEY ISLAND
NARROWS
STATEN ISLAND
SANDY HOOK
NEW YORK
NEW JERSEY
NEW JERSEY
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
ZONE A
ZONE B
ZONE C
ZONE D
ZONE E
ZONE F
MILES
1
0
1
2
3
4
5

FIGURE 2

GPO 956-592

Table 1

Bathing Beaches Surveyed

1. South Beach
2. Ocean Edge Colony, Inc.
3. Clearwater Beach
4. Cedar Grove Beach Club
5. Great Kills Park
6. Great Kills Beach
7. Groton Street Beach
8. Seacrest Avenue Beach
9. Prol's Beach
10. Bennet Place Beach
11. Barclay Avenue Beach
12. Lippset Avenue Beach
13. Poillon Avenue Beach
14. Arbutus Beach
15. Huguenot Beach
16. Wolf's Pond Park
17. Seguine Point Beach
18. Princess Bay Cabana Club
19. Mount Loretto Beaches
20. Tottenville
21. Chelsea (Staten Island)
22. Sewaren Beach
23. James Street (E. Perth Amboy)
24. Perth Amboy
25. South Amboy
26. Paul's Beach
27. Laurence Harbor Beach
28. Open Beach @ Laurence Harbor
29. Cat 'N Fiddle Beach
30. Keyport - Broad Street
31. Keyport - Cedar Street
32. Union Beach
33. Laurel Avenue - Keansburg
34. Pinewood Ave-Carr Ave-Keansburg
35. Keansburg Public Beaches #1,2,3,4,5
36. Lighthouse Beach
37. Beacon Beach
38. Ideal Beach
39. Pews Creek
40. Barret Avenue Beach
41. Cullom's Beach
42. Bayside Way
43. Middletown Township Beach
44. Franklin Avenue Beach
45. Brevent Avenue Beach
46. Camp Happiness Beach
47. Atlantic Highlands Municipal Beach
48. Harborview Drive Beach
49. Torok's Beach
50. Doris 'N Ed's Picnic Beach
51. Mt. Mitchell Beach
52. Lynch's Beach
53. Conner's Hotel Beach
54. Cravely Point Beach
55. Waterwitch Beach
56. Atlantic Street Beach
57. Alley Avenue West Beach
58. Alley Avenue East Beach
59. Highlands Public Beaches #1,2,3

Note: Numbers refer to beach locations in Figure 2.

Table 2

Area Frontage and Value at Bathing Beaches

Zone	MUNICIPALLY-OWNED BEACHES Frontage (Ft)	Land Area (Acres)	Land Value ($)	Improvement Value ($)	PRIVATELY-OWNED BEACHES Frontage (Ft)	Land Area (Acres)	Land Value ($)	Improvement Value ($)
A	830	3.50	50,940	2,600	4,945	39.35	207,300	233,900
B	3,606	8.56	119,300	41,000	14,650	122.87	375,528	842,500
C	6,500	107.37	305,800	78,000	13,800	15.80	244,000	0
D	3,000	229.00	2,100,000	121,000	5,517	43.76	616,180	238,400
E	28,675	877.93	19,543,400	2,620,000	0	0	-	-
F	650	0.30	16,500	0	80	0.46	1,265	0
Total	43,261	1226.66	22,135,940	2,862,600	38,992	222.24	1,444,273	1,314,800

Table 3

Income, Bathers and Employees in the Bathing Beaches

Zone	No. Employed Year Round	No. Employed Summer	Gross Income Per Year ($)	Bathers Per Season	Salaries ($)
A	4	14	78,060	80,860	35,500
B	13	151	261,575	157,940	138,414
C	0	18	2,000	38,000	12,600
D	26	44	188,246	206,125	106,702
E	22	237	219,966	581,868	401,023
F	0	0	0	4,350	0
Total	65	464	749,847	1,069,143	748,239

Table 4 presents a summary of bacteriological data on the water quality at the Staten Island beaches, areas D and E in Figure 2 for the periods May through August 1963 and 1964. The sampling station locations are shown in Figure 3.

The geometric means of confirmed coliform MPNs at Stations 601, 602, 603 and 604 exceeded the recommended limits for bathing waters of 1,000 per 100 ml as adopted by the New York City Department of Health. Three of these stations had confirmed MPN coliform geometric means in excess of 2400 per 100 ml, the maximum limit allowed for bathing waters by the New York City Department of Health.

As a result of high bacteriological counts observed in the water, the New Jersey State Department of Health has closed the Perth Amboy bathing beach.

Area F where three bathing beaches were located consists of the Arthur Kill. The waters of the Arthur Kill have been classified as Class B by the Interstate Sanitation Commission, which does not provide for recreational bathing. Hence, the three beaches in this area are in contravention of existing legal classification standards for these waters.

Table 4

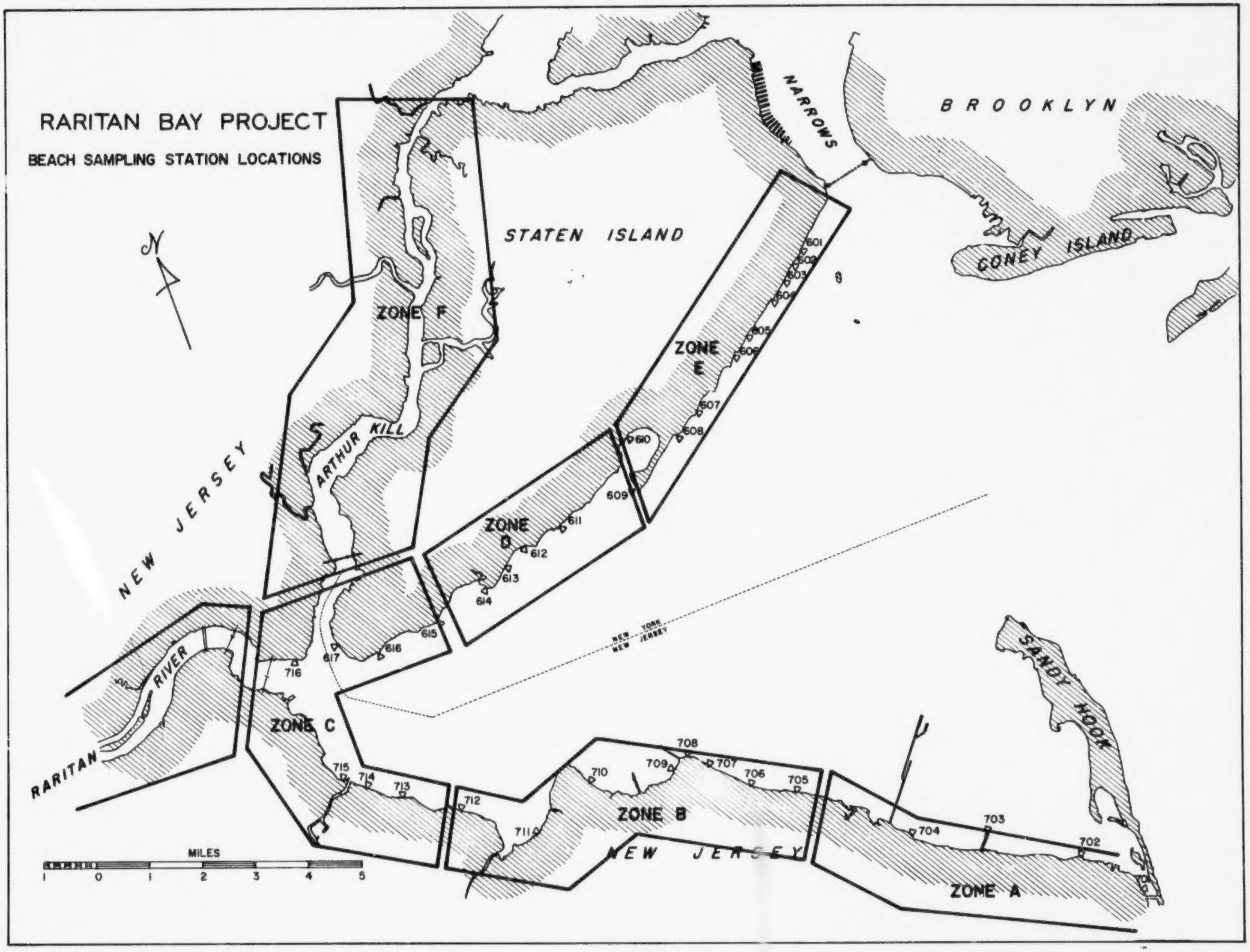
Summary of Bacteriological Data, May-August 1963

Shore Stations

Zone	Station	Confirmed Coliform			Fecal Coliform		Fecal Streptococcus	
		No. Samples	Geom. Mean /100 ml	No. of samples Greater Than 1000/100 ml	No. Samples	Geom. Mean /100 ml	No. Samples	Geom. Mean /100 ml
A	701	18	48	0	14	15	18	16
	702	19	208	4	15	40	19	33
	703	18	34	0	15	10	19	13
	704	19	57	1	15	20	19	28
B	705	19	151	3	15	30	19	53
	706	18	178	2	15	40	19	52
	707	19	324	3	15	30	18	46
	708	18	497	4	15	90	18	130
	709	17	390	5	15	30	18	82
	710	19	361	4	16	30	19	39
	711	17	295	4	16	30	18	48
	712	18	302	2	16	25	18	85
C	713	18	938	8	16	40	18	132
	714	17	532	4	15	30	17	178
	715	17	399	4	16	50	18	137
	716	17	5,478	13	16	330	17	82
	615	8	400	2	5	40	8	126
	616	14	566	4	11	60	14	376
	617	13	160	-	10	70	13	226

Table 4 Cont'd.

Zone	Station	Confirmed Coliform			Fecal Coliform		Fecal Streptococcus	
		No. Samples	Geom. Mean /100 ml	No. of samples Greater Than 1000/100 ml	No. Samples	Geom. Mean /100 ml	No. Samples	Geom. Mean /100 ml
D	611	17	348	3	14	40	17	155
	612	17	410	4	14	50	17	138
	613	17	205	1	14	30	17	169
	614	13	403	4	11	80	13	214
E	601	15	14,044	15	14	1,600	16	174
	602	17	7,895	15	15	700	18	63
	603	18	4,908	15	15	700	19	79
	604	17	2,219	13	14	220	17	23
	605	17	476	3	15	60	18	51
	606	17	627	6	15	40	18	44
	607	18	174	2	15	30	18	31
	608	17	153	1	14	20	17	49
	609	14	97	2	11	25	14	25
	610	-	-		-	-	-	-



RARITAN BAY PROJECT

BEACH SAMPLING STATION LOCATIONS

BROOKLYN
NARROWS
CONEY ISLAND
STATEN ISLAND
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
SANDY HOOK
NEW YORK
NEW JERSEY
ZONE A
ZONE B
ZONE C
ZONE D
ZONE E
ZONE F
N
MILES
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FIGURE 3

GPO 956-592

PROJECTIONS

On a regional, as well as a national basis, recreational bathing is receiving increased attention and growth. Between 1945 and 1955, attendance at bathing parks in Nassau and Suffolk Counties in Metropolitan New York nearly quadrupled while the combined population only doubled. (2) Studies by the Federal Outdoor Recreation Resources Review Commission indicate that by the year 2000, recreational bathing will be the most popular single outdoor recreation, exceeding even automobile driving for pleasure, which now holds first place. (3)

The usefulness of a given body of water for recreational bathing depends on four factors: water quality, proximity of population, accessibility, and suitability for use. Assuming adequate water quality is attained, the large population adjacent to Raritan Bay should result in increasing use of this water for bathing.

Past and projected populations for Staten Island (Richmond County), New York, and the four counties in New Jersey closest to Raritan Bay are as follows: (2)

	Population in Millions			
	1955	1965	1975	1985
Staten Island, N.Y.	0.20	0.32	0.42	0.48
Four N.J. Counties*	1.18	1.87	2.76	3.79
TOTALS	1.38	2.19	3.18	4.27

*Middlesex, Monmouth, Somerset and Union Counties.

Construction of the Verrazano-Narrows Bridge has resulted in making the beaches of Staten Island readily accessible to persons living in Brooklyn. Hence, the figures above could be revised upward to make allowance for an additional 1,000,000 or more persons in close proximity to the beaches of Raritan Bay.

It is estimated that over 40 percent of the population prefer water based recreation. (3) On this basis, by 1985, more than 2,000,000 persons in the immediate area and Brooklyn will be looking to Raritan Bay waters for recreation. Increased population throughout the Metropolitan Region, coupled with better highways and more rapid transportation will place an ever increasing demand for water based recreation in the area.

Experience in the New York Metropolitan Region shows bather densities vary rather widely, from five persons per acre at Orient Beach State Park on Long Island to 4000 persons per acre at Coney Island. (2) Sandy Hook

State Park, just south of the Project study area had an average bather density of more than 200 bathers per acre per day for the bathing season included in the period July 1, 1963 to June 30, 1964. Hence, if adequate water quality were attained, a future density of at least 150 persons per acre per day, similar to the conditions now found at Jones Beach State Park in New York, can be projected for the Raritan Bay beaches. With the currently active bathing beaches, this would result in nearly 16,000,000 bather days for a 73 day season as experienced in 1963, equivalent to a value of nearly $8,000,000 per year based upon $0.50 per recreation day. In addition, the development of additional beach areas to meet the demands of an increasing population, especially in the undeveloped areas of Middlesex and Monmouth Counties, New Jersey could easily increase the projected value to $12,000,000 annually.

FINDINGS AND CONCLUSIONS

1. In 1963, there were 59 active bathing beaches on Raritan Bay and the Arthur Kill; of these 17 were municipally-owned, and 42 were privately-owned.
2. These bathing beaches had a land value of $23,600,000, while improvements totalled $4,200,000.
3. Use of these bathing areas was light, with an average density of only 10 persons per acre. Based upon $0.50 per bather-day, the value of recreational bathing in 1963 was only $500,000.
4. Water at many of the Raritan Bay beaches was of a low quality. Geometric means of confirmed coliform counts at three stations exceeded the minimum limits for bathing established by the New York City Department of Health.
5. If suitable water quality were attained, the bathing industry in Raritan Bay could expand to a value of $12,000,000 annually, based upon $0.50 per bather-day.

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1. "Supplement No. 1, Evaluation Standards for Primary Outdoor Recreation Benefits" by the Ad Hoc Water Resources Council, Washington, D.C. June 4, 1964.
2. RPA Bulletin No. 96 - "The Race for Open Space" (Final Report of the Park, Recreation and Open Space Project of the Tri-State New York Metropolitan Region), 1960, for Metropolitan Regional Council and Regional Plan Association.
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BOAT POLLUTION - RARITAN BAY

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Summary

As part of its program to collect scientific data on pollution of the waters of Raritan Bay, the Raritan Bay Project, Federal Water Pollution Control Administration, U.S. Department of the Interior, (formerly Public Health Service, U.S. Department of Health, Education, and Welfare) studied available information to determine the effects on water quality of commercial navigation in the Bay and conducted a survey of recreational boating to estimate the magnitude of pollution from this source.

This study showed that the New York - New Jersey Channel which traverses Raritan Bay is an important part of New York Harbor. Approximately one-fourth of the larger vessel traffic entering or departing the port traverses this channel. In both 1960 and 1961, annual totals of more than 120,000 vessel trips were made through Raritan Bay Channels. Of these, 4,000 trips annually were made by ships of 20 feet draft or larger.

Projections of future commercial traffic indicated that by 2015, the New York - New Jersey Channel will handle 200,000 vessel trips annually, of which 6,000 trips will be made by ships of 20 feet draft or larger.

The evaluation indicated the major pollution problems associated with commercial navigation in the bay, both now and in the future, are local problems in the area of docks and berths rather than pollution in transit and anchorages.

Introduction

Purpose and Scope

As a part of its overall mission to collect and evaluate scientific data related to water pollution and its control in Raritan Bay, the Raritan Bay Project reviewed and evaluated existing information on the extent of commercial navigation within the study area, so as to determine the magnitude of the water pollution problem associated with such shipping. In addition, the Project conducted a survey of recreational boating within the study area to determine the effects of such boating upon water quality. The study area is shown in Figure 1.

Sources of Data

Information on the present commercial vessel traffic and industry trends were obtained from the published records of the U.S. Army Corps of Engineers. From these date, the present and future pollution loads associated with this water use were estimated.

Information on recreational boating within the study area was obtained as a result of a survey conducted in 1963 by the staff of the Project. Details on this survey have been reported in Appendix C.

Present and Future Navigational Use

Present Traffic

The study area is adjacent to, and forms a portion of the Port of New York, one of the world's busiest seaports. The shipping channels in the study area are shown on Figure 1. All of these channels have depths at mean low water in excess of 30 feet. In addition to the channels, the study area contains 11 designated anchorage areas, all unimproved.

Table 1 presents the vessel trips in the New York Harbor Entrance Channels for the period 1952 to 1961. These data are counts of vessels passing the outer bar of Ambrose and Bayside Channels, the two ocean entrances to New York Harbor. The number of trips annually has shown only minor variation during this decade, and averages 36,000 vessel trips per year. Of this total, one-half is due to vessels with drafts of less than 20 feet, made up of coastline traffic adjacent to New York Harbor, such as large tows and dump scows which unload beyond the channel outerbar. While the total annual vessel trips has remained constant, there has been a large decrease in the number of trips by vessels under 20 feet draft, with an accompanying increase in larger vessels, especially in the 34 to 38 foot draft category.

Table 2 shows vessel trips for 1960 and 1961 through the New York and New Jersey Channel, which runs through Raritan Bay from the Bayside Channel to the Arthur Kill. Total vessel traffic for each of these years amounted to over 120,000 trips. However, only 4,200 of these trips were made by vessels of 20 feet or more draft.

Possible routes for vessels entering and leaving the New York Harbor complex can be seen by the configuration of shipping channels in Figure 1. Vessels entering from the ocean via the Ambrose and Bayside Channels can proceed either through the Narrows into New York Harbor proper, or to the Arthur Kill and Raritan River via the New York and New Jersey Channel. Departing vessels would travel the same routes, except for a tendency to avoid turning the larger vessels in the Arthur Kill due to the narrow channel width. Larger vessels generally enter the Kill from Raritan Bay and continue so as to depart through Newark Bay, Kill Van Kull and the Upper Harbor, or travel the reverse direction.

A comparison of data for 1960 and 1961 in Tables 1 and 2 indicate the general proportion of traffic movement. In each year, 18,500 trips were made by vessels of 20 foot draft or larger. Only 4,200, or one-fourth, of these trips utilized the New York and New Jersey channel, while the remainder generally travelled through the Narrows.

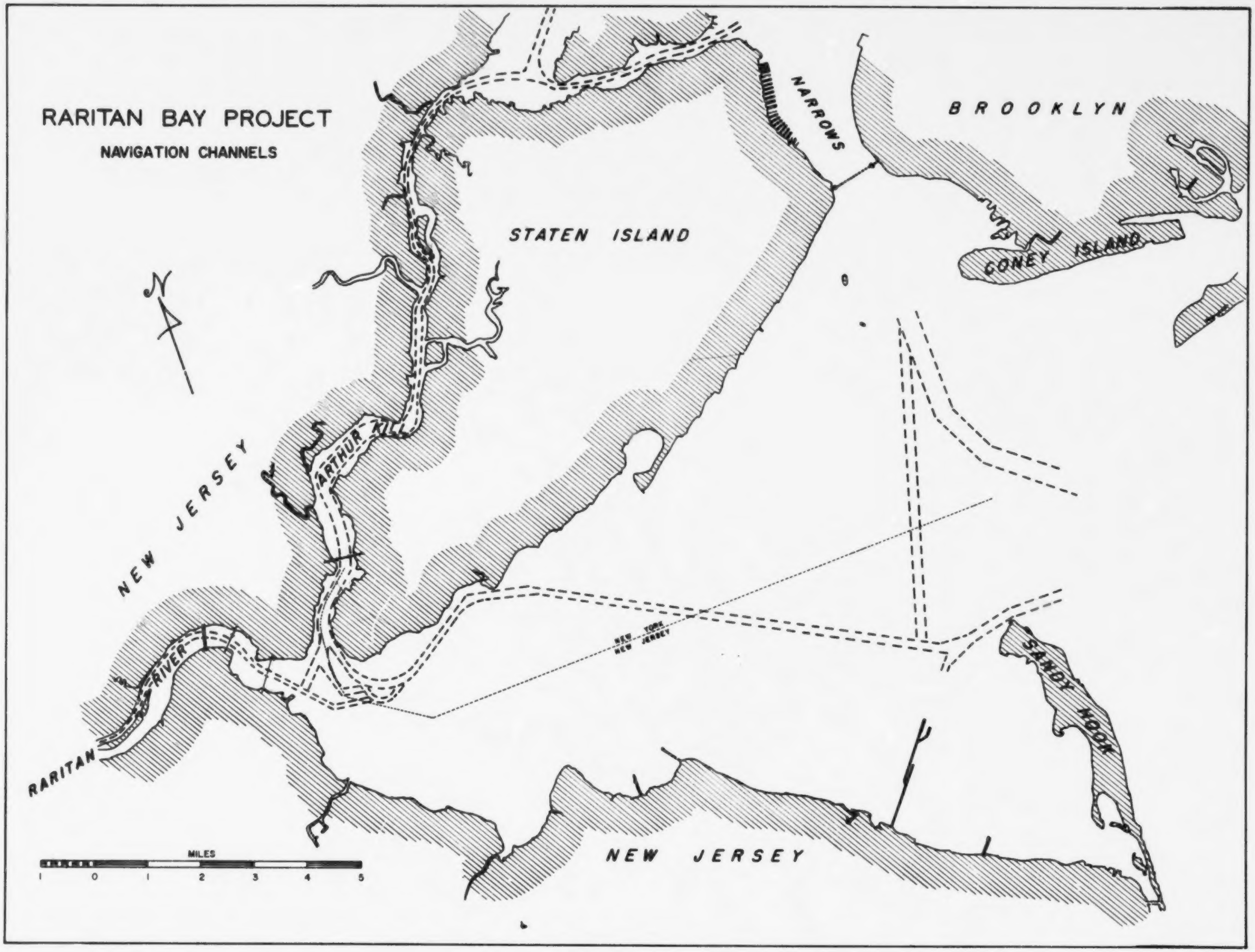
RARITAN BAY PROJECT
NAVIGATION CHANNELS
N
BROOKLYN
NARROWS
CONEY ISLAND
STATEN ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
SANDY HOOK
NEW JERSEY
MILES
1 0 1 2 3 4 5

FIGURE I

GPO 956-592

Table 1

New York Harbor Entrance Channels
Trips of Vessels of Various Drafts - 1952 to 1961

(Ambrose and Bayside - Gedney Channels)

	Number of Vessel Trips for Indicated Drafts in Feet						
Year	38 and Over	34 to 37.9	30 to 33.9	25 to 29.9	20 to 24.9	Less Than 20	All Drafts
1952	72	101	2,678	4,479	7,555	21,029	35,914
1953	73	86	2,859	4,507	8,172	23,842	39,539
1954	84	104	2,868	4,180	7,850	23,232	38,318
1955	73	188	3,134	4,845	8,140	19,065	35,405
1956	86	219	3,373	5,047	7,923	20,206	36,854
1957	71	401	3,092	4,912	8,326	18,546	35,348
1958	69	553	2,783	4,705	8,940	17,256	34,306
1959	79	596	2,801	4,880	9,352	18,691	36,399
1960	69	757	2,661	4,850	10,161	18,376	36,874
1961	71	985	2,414	4,758	10,303	14,888	33,419
Average	75	399	2,866	4,716	8,668	19,513	36,237

Table 2

New York & New Jersey Channel Traffic, 1960 and 1961

Type of Vessel	Inbound							Outbound						
	38 and Over	34 to 37.9	30 to 33.9	25 to 29.9	20 to 24.9	Less Than 20	All Drafts	38 and Over	34 to 37.9	30 to 33.9	25 to 29.9	20 to 24.9	Less Than 20	All Drafts
CALENDAR YEAR 1960														
Self-Propelled Vessels														
Passenger & Dry Cargo	-	-	4	74	95	16,413	16,586	-	-	1	27	30	16,466	16,524
Tanker	4	594	1,441	177	142	11,601	13,959	-	6	126	260	1,153	12,410	13,955
Tow or Tug Boat	-	-	-	-	-	22,559	22,559	-	-	-	-	-	22,559	22,559
Towed Vessels														
Dry Cargo	-	-	-	-	9	8,220	8,229	-	-	-	-	27	8,217	8,244
Tanker	-	-	-	-	64	10,883	10,947	-	-	-	-	20	10,927	10,947
Totals 1960	4	594	1,445	261	310	69,676	72,280	-	6	127	287	1,220	70,579	72,229
CALENDAR YEAR 1961														
Self-Propelled Vessels														
Passenger & Dry Cargo	-	-	4	79	122	12,336	12,541	-	-	3	19	68	12,356	12,446
Tanker	9	665	1,132	191	116	9,659	11,772	-	6	81	347	1,243	10,436	12,113
Tow or Tug Boat	-	-	-	-	-	18,950	18,950	-	-	-	-	-	19,175	19,175
Towed Vessels														
Dry Cargo	-	-	-	-	7	6,064	6,071	-	-	-	-	13	6,004	6,017
Tanker	-	-	-	-	20	9,925	9,945	-	-	-	-	32	10,284	10,316
Totals 1961	9	665	1,136	270	265	56,934	59,279	-	6	84	366	1,356	58,255	60,067

	1960	1961
Total Vessel Trips, All Drafts	144,509	119,346
Total Vessel Trips, Drafts 20 feet or more	4,254	4,157
Tanker Vessel* Trips, Drafts 20 feet or more	3,903	3,790
Total Self-Propelled Vessel Trips, All Drafts		86,997

*Self-propelled only

Additional vessel traffic in the area which is not included in Tables 1 and 2 is that flowing between the Raritan River and the Arthur Kill, and that in the area of Sandy Hook Bay. The traffic in these areas, for vessels of 20 foot or more draft, is known to be small in comparison to the channels discussed above, although considerable traffic does exist for smaller vessels.

Future Projections

The trend over the past decade toward larger vessels is shown by Table 1. Trips by vessels with drafts of 34 to 37.9 feet increased nearly ten-fold during the period 1952 to 1961, while there was a gradual reduction in trips by vessels of less than 20 foot draft. At present, about one-half of the tankers entering the New York Harbor complex are of the T-2 class, built during World War II. These vessels generally have a draft of 30 to 31 feet, and a capacity of 17,000 dead weight tons. The remaining tankers are generally post-World War II, with capacities of 20,000 to 40,000 tons. In recent years, tankers as large as 100,000 dead weight tonnage have been constructed. Table 3 presents the size of tankers under construction as of July 1, 1962 for three maritime nations, and illustrates the trend toward tankers larger than the T-2 class.

At present, the dry cargo ships entering New York Harbor range in length from less than 300 to 600 feet and in draft from 20 to 33 feet. Table 4 presents data on typical dry cargo ships ordered as of June 1961 by United States operators, and illustrates that these new vessels, while large, are still within the range of ships now in service.

Studies of tanker trends made by the Corps of Engineers, the Suez Canal Company and others indicate that the majority of tankers in the New York Harbor complex over the next 50 years will be of the medium size, i.e., 45,000 deadweight tonnage. Hence, although the petroleum commerce is expected to increase over this period of time, these larger vessels will require fewer trips to carry this commerce. It is estimated that 3,100 round trips, or 6,200 vessel trips will be made annually by tankers to and from the New York Harbor complex 50 years from now.

On the basis of average annual prospective dry cargo commerce in New York Harbor for the next 50 years, it is anticipated that about 10,000 freighters with drafts over 20 feet will enter New York Harbor annually, i.e., 20,000 vessel trips through the Ambrose and Bayside Channels.

Table 5 presents a projection of traffic for the year 2015 in the New York and New Jersey channel through Raritan Bay, based upon the above estimates of total New York Harbor commerce. The assumptions used in this projection were that the present percentage of total traffic for vessels of 20 feet draft and larger which use the New York - New Jersey channel would remain constant, and that trips of vessels with less than 20 feet draft and towed vessels would increase proportionately with the larger vessel traffic. These assumptions result in a projected commercial navigation load in 2015 of 200,000 vessel trips annually through the New York - New Jersey channel bisecting Raritan Bay. Of this total, 6,000 vessel trips will be made by vessels of 20 feet and more draft.

Table 3

Tankers Under Construction for U.S., Liberian & Panamanian Flags, 1962

Dead-weight Tonnage	Approx. Draft Ft.	No. of Vessels U.S.	Liberian	Panama	Total	% of Total Vessels
18,000	31	0	1	0	1	1
25,000-36,000	33-36	6	1	3	10	16
36,001-45,000	36-38	0	0	0	0	-
45,001-55,000	38-40	4	27	2	33	55
55,001-66,000	40-42	0	0	0	0	-
66,001-70,000	42-43	0	10	0	10	16
70,001-80,000	43-45	0	7	0	7	11
150,000	45+	0	1	0	1	1

Table 4

Cargo Vessels Ordered by United States Operators
(As of June 1961)

Vessel Type	Length Feet	Beam Feet	Draft Feet	Dead-Weight Tonnage	No. of Vessels
C3-S33a	484	68	28.5	12,300	8
C3-S37b	495	69	28	11,000	17
C3-S38a	492	73	27	11,000	4
C3-S46a	493	73	27	12,800	8
C3-S43a	506	70	28	13,100	3
C4-S19	564	76	30	14,000	2
C4-S1a	564	76	27	15,000	3
C4-S1t	565	76	30	13,700	2
C4-S49a	545	79	27	9,300	3
C4-S11u	565	76	30	14,300	6
C4-S58a	574	75	30.5	12,600	6
C4-S57a	560	75	28.5	12,000	11

Table 5

PROJECTION OF TRAFFIC IN NEW YORK & NEW JERSEY CHANNEL IN YEAR 2015

Total Trips, Vessels 20' draft & larger, Ambrose & Bayside Channels, 1960	18,498 [1]
Total Trips, Vessels 20' draft & larger, New York & New Jersey Channels, 1960	4,254 [2]
Percent of Ambrose-Bayside Traffic to NY-NJ Channel	23%
Estimated Trips, Vessels 20' draft & larger, Ambrose & Bayside Channels, 2015	26,200 [3]
Projection Trips, Vessels 20' draft & larger, New York & New Jersey Channels, 2015	6,000 [4]
Percent Increase in NY-NJ Channel Trips for Vessels 20' draft and larger, 2015	41%
Present Traffic, Vessels less than 20' draft, NY-NJ Channel, 1960	140,255 [2]
Future Traffic, Vessels less than 20' draft, NY-NJ Channel, 2015	198,000 [5]
Total Vessel Trips, NY-NJ Channel, 2015	204,000

---

[1] From Table 1.

[2] From Table 2.

[3] From Text, 6200 tanker and 20,000 dry cargo.

[4] 23% of 26,200.

[5] Assuming same percentage increase for small vessels as that for vessels 20' or more draft.

POLLUTION FROM COMMERCIAL NAVIGATION

No field studies were made of the pollution from vessels engaged in commercial navigation. Calculations were made to estimate the order of magnitude of water pollution from this source.

Table 6 was prepared to suggest the size of the problem of fecal pollution from commercial vessels in Raritan Bay, based upon the data in Table 2. In preparing Table 6, it was assumed that self-propelled vessels of less than 20 feet draft were generally tugs, which did not use the anchorage or dockside areas to any significant extent. Similarly, towed vessels of all sizes were considered as barge traffic with one man crews and were eliminated from use of anchorage and berth areas.

On the basis of these assumptions, Table 6 indicates the major problem of fecal pollution from commercial vessels is concentrated in the berthing area, where the equivalent population was estimated as 600 persons. Pollution while in anchorage, or from vessels in transit, was equal to a population of less than 100 persons.

With the projected increase of 50% in vessel trips with draft of 20 feet or more, a proportionate projection of the figures in Table 6 would indicate the major future problem would also be localized in the berthing areas.

The Interstate Quarantine Regulations govern the discharge of polluting materials from commercial vessels engaged in interstate traffic. A special Committee appointed to investigate the pollution problems associated with commercial vessels has proposed the following be included in the Regulations: "SEWAGE TREATMENT. New vessels undergoing major conversion, that will operate in interstate traffic under the terms of these regulations, that are contracted for after the effective date of this section, shall be equipped with facilities to treat wastes from toilets, urinals, facilities in hospital areas handling fecal material and wastes from garbage grinders when such grinders are installed. In lieu of treatment, these wastes may be collected in holding tanks properly equipped with pumps and piping, so that the wastes can be discharged to approved shore-based or floating installations, or on the high seas."

Table 6 does not include pollutional loads which occur as a result of the discharge of oil and other bilge waste, discard of trash, garbage and other debris, and spillages at dockside during cargo transfer. No evaluation was made of these sources, as existing laws controlling this pollution are in effect at all levels of governments, State, Interstate and Federal.

PRESENT AND FUTURE RECREATIONAL BOATING

A survey of recreational boating in Raritan Bay by the staff of the Raritan Bay Project found a total of 5,480 recreational boats located at marinas and berths within the study area. In addition, a further vessel use of one-half that surveyed was estimated as attributable to transient visitors from outside the survey area either via water or as automobile trailed boats.

Based upon expected changes in population, income, leisure, and mobility, recreational boating in the bay is expected to be greatly increased. Since the population in the five counties adjacent to the bay will virtually double by 1985, it would appear that recreational boating would also at least double over this period. Estimates of future pollution loadings were made on this basis.

POLLUTION FROM RECREATIONAL BOATS

Pollution of water by recreational boating may occur in a number of ways: discharge of human wastes; fuel and oil from spillage and engine exhaust; discard of trash and garbage; and chumming when the boats are used for fishing.

Of the 5,480 boats surveyed in 1963, 1,845 had toilet facilities aboard. Only 46 of these had some provision for treatment of the waste before discharge, generally chlorination.

Estimates were made to determine the order of magnitude of the problem of fecal pollution from recreational boats, on the assumptions that all of the boats surveyed with toilet facilities were in use, and that an additional 50 percent of this number were present as transient visitors from outside the survey area, as would occur on a weekend or a holiday. The calculations are presented in Table 7. The present BOD load from this activity is 725 pounds per day, equivalent to a municipality of 4,300 persons. After deducting the waste from those boats which provide treatment, i.e., chlorination, the bacterial loading is equivalent to the raw sewage discharge from 5,900 persons.

Assuming that recreational boating doubles by 1985, the pollutional load on this activity will become even more significant than at present. If the present proportion of boats with treatment remains constant, the resulting equivalent population by 1985 would be more than 10,000 persons.

Although this pollution source is spread over the Bay rather than concentrated at a particular point, the magnitude of this pollution is sufficient to warrant control. In particular, the discharge of raw wastes from recreational boats directly over open shellfish areas presents a sanitary problem with definite public health significance. Further study of this problem and the development of adequate treatment facilities are required to insure proper control of pollution from recreational boating.

TABLE 6

ESTIMATED FECAL POLLUTION FROM COMMERCIAL NAVIGATION - 1961

(NY - NJ Channel)

Vessel Category	1961 Vessel Trips 1/	Estimated Crew Size	Man days in Transit 2/	Equivalent Transit Population 3/	Man days in Anchorage 4/	Equivalent Anchorage Population 3/	Man days at Dockside 5/	Equivalent Dockside Population 3/
Self-Propelled, Draft 20 feet or more	4,085	35	2,970	8	23,800	65	220,000	600
Self-Propelled, Draft less than 20 feet	82,912	15	25,900	71	6/	6/	6/	6/
Towed, all Drafts	32,349	1	675	2	6/	6/	6/	6/
TOTALS	119,346	-	-	81		65		600

1/ From Table 2.

2/ Assuming 30 minute channel transit time.

3/ Man days ÷ 365 to convert to 365 day year population.

4/ Assuming 1/3 of vessels use anchorage area for 12 hours each.

5/ Assuming 3 day tie-up at dock for each pair of vessel trips (i.e., incoming - 3 day berth - outgoing).

6/ No value calculated on the assumption that self-propelled vessels less than 20 feet draft and towed vessels consist of tugs and barges and do not utilize the anchorage and dockage facilities.

Table 7

FECAL POLLUTION RESULTING FROM RECREATIONAL BOATING

Number of Boats Surveyed	5,480	
Number Surveyed with Toilets	1,845	
Estimated Transit with Toilets	900	
Total Boats with Toilets		2,745
Average Population Per Boat	4.4	
Estimated Hours of Use	12	
Tributary Population, capita-days	6,040	
BOD Load in lbs per Day [1]	725	
BOD Equivalent Population [2]	4,300	
Number of Boats with Toilets but No Treatment	1,799	
Estimated Transit with Toilets but No Treatment	880	
Total Boats with Toilets but no Treatment		2,679
Coliform Equivalent Population [3]	5,900	

[1] Assuming a per capita contribution for domestic sewage of 0.12 lbs (Fair & Geyer, Water Supply and Waste-Water Disposal, Wiley & Sons, 1954, Pg. 563).

[2] At 0.17 lbs per capita for municipal sewage.

[3] Assuming boat population and hours of use given for BOD calculations.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of available data and field surveys of present commercial vessel traffic and recreational boat use in Raritan Bay, and projections of future growth of such uses, the following conclusions were reached:

1. Raritan Bay is traversed by several commercial shipping channels and forms an important part of the Port of New York complex;
2. Approximately one-fourth of the larger vessel traffic entering or departing the Port of New York travels the New York-New Jersey channel through Raritan Bay. In both 1960 and 1961 an annual total of approximately 4,200 vessel trips were made through this channel by vessels with drafts of 20 feet or more;
3. It is expected that by the year 2015, 6,000 vessel trips will be made annually through the New York-New Jersey channel by vessels with drafts of 20 feet or more.
4. Present and future fecal pollution from commercial navigation is of greatest concern in local dockside areas. Pollution from these vessels while in transit or in anchorage is much less significant.
5. There are existing pollution control laws at all levels of government which forbid the discharge of oil and pumping of bilge wastes by commercial vessels while in these waters.
6. The present fecal pollution from recreational boating is estimated to be equivalent to 4,300 persons on a BOD basis and 5,900 persons on a bacterial loading basis.
7. Projected increases in recreational boating indicate that by 1985 the equivalent population from this source will be more than 10,000 persons.

With the proposed clean-up of the waters of the Raritan Bay as an out-growth of the existing and proposed programs of state, interstate and local agencies, the problem of pollution from commercial vessels and from recreational boating becomes more significant. In the light of this the following recommendations are made:

1. Existing laws regulating oil discharge and bilge waste pumping continue to be enforced at all levels of government;
2. Provisions be made within commercial vessel docking areas for the transfer of fecal wastes to shore-based treatment and disposal systems.
3. The proposed changes to the Interstate Quarantine Regulations requiring adequate treatment facilities or in transit storage facilities for commercial vessels be adopted;
4. Further study and development of adequate treatment means be made so as to control the discharge of sewage from recreational boats.

GEOLOGY OF RARITAN BAY

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SUMMARY

During July and August 1963, the Raritan Bay Project, Federal Water Pollution Control Administration, U.S. Department of the Interior (formerly Public Health Service, U.S. Department of Health, Education, and Welfare) conducted a geological investigation of Raritan Bay to define water movement in the bay by the sediment pattern.

The study included a review of available chloride data, as well as sampling and analyses of the bay sediment. Sediment samples were subjected to size analyses and determinations of water, organic matter and carbonate content. The distribution of these readily identifiable sediment particles, the mineral muscovite, the shell of the small clam _Mulinia_ _lateralis_, and detrital coal, was studied to determine net movement of such particles in the bay.

Major conclusions from this investigation include the following:

1. The shoreline of the Raritan estuary has reached early maturity in the geomorphic cycle of shoreline development.
2. Movement of high chlorinity water is centered in the northerly portion of the bay, while fresher water moves through the southern portion.
3. The bay floor is made up of four major sediment bodies, referred to as the Lower Bay and Keansburg Sands, and the Sandy Hook Bay and West Raritan Bay muds.
4. The high organic carbon content found in West Raritan Bay is due to small particles of organic matter, probably the result of organic matter introduced through pollution.
5. Sediment particles originating at various locations in the bay are moved progressively toward the area bounded by Sequine Point, Great Kills, Keyport and Keansburg.

INTRODUCTION

As part of its work in gathering scientific data relating to pollution of the waters of Raritan Bay, the Raritan Bay Project investigated the geology of Raritan Bay. During July and August 1963 sampling and analysis was carried out to determine sediment types and distribution, as well as sediment water, organic and carbonate content.

In addition to providing general knowledge of the Bay area, the purpose of the study was to attempt to define water movement in the Bay as evidenced by the general sediment pattern.

DESCRIPTION OF AREA

GENERAL

Raritan Bay is a triangular-shaped estuary which opens eastward to the Atlantic Ocean. It lies directly adjacent to the New York Metropolitan area, as shown in Figure 1. Although collectively referred to in this report as Raritan Bay, the estuary is actually composed of three bodies of water, Raritan Bay proper, in the western and southern area, Lower New York Bay in the north, and Sandy Hook Bay in the southeast. The principal external sources of water entering the bay in addition to the Atlantic Ocean are the Raritan River, Arthur Kill, and the Narrows.

BEDROCK GEOLOGY

The geologic formations and their areas of exposure are shown in Figure 2. Rocks of less than 1 million years age form the shores of a large portion of Raritan Bay. The terminal moraine of the latest continental glacier, the Wisconsin Ice Sheet, bounds the bay to the north in the area from Perth Amboy to Great Kills. From Great Kills east to the Narrows the Staten Island shore consists of sands of less than 1 million years; i.e., of Quaternary age. The New Jersey shore from Keyport to Leonardo as well as Sandy Hook are also composed of Quaternary sands.

The older sands, gravels and clays underlying Raritan Bay and the rocks exposed along the shore of the bay in the areas not described above are all of the Upper Cretaceous age and were deposited between 100 and 70 million years ago.

PHYSIOGRAPHY

Sea cliffs are shoreline features resulting from marine erosion.(1) On the Raritan Bay shore, these cliffs are found on Staten Island, westward from Seguine Point to the Arthur Kill and on the New Jersey shore between Cliffwood and the Raritan River and between Leonardo and Highlands.

Wide beaches are shoreline features which result from marine deposition.(1) Sections along Raritan Bay with such beaches are the Staten Island shore from Seguine Point eastward to the Narrows, the New Jersey shoreline between Keyport and Leonardo, and Sandy Hook.

The shorelines of Raritan Bay are relatively straight compared to those of most Atlantic Coast estuaries. Shorelines of erosion and deposition show linear continuity with one another.

The bay is relatively shallow and its floor slopes fairly uniformly and gently toward the center of the bay where its maximum depth is about 27 feet. The mouth of the bay is marked by a north-south series of shoals and bars, including Sandy Hook, Flynn's Knoll, Romer Shoal and West Bank. None of the beach areas show offshore bars. Tidal marshes are present on the New Jersey shore.

Since sea level has risen several hundred feet in the past 10,000 years, Raritan Bay is of rather recent submergence. The bay has reached early maturity in the cycle of shoreline development along submergent coasts. The straight shorelines, uniform slope of the floor and the absence of offshore bars satisfy the conditions for maturity, although the presence of tidal marshes indicates that full maturity has not yet been attained.(1)

HYDROGRAPHY

Previous studies have shown that ocean water enters the bay on the north, river water moves along the south shore, and mixing occurs along the long axis of the bay.(2) The seaward drift of fresh water on the southern part of the bay is horizontally separated from the landward counter drift in the area where the bay widens. Surface waters are of lower salinity than bottom waters.(3) Water from the east enters the bay off Staten Island, moves westward toward Staten Island, but then is recirculated along the beach in a northeasterly direction.(4)

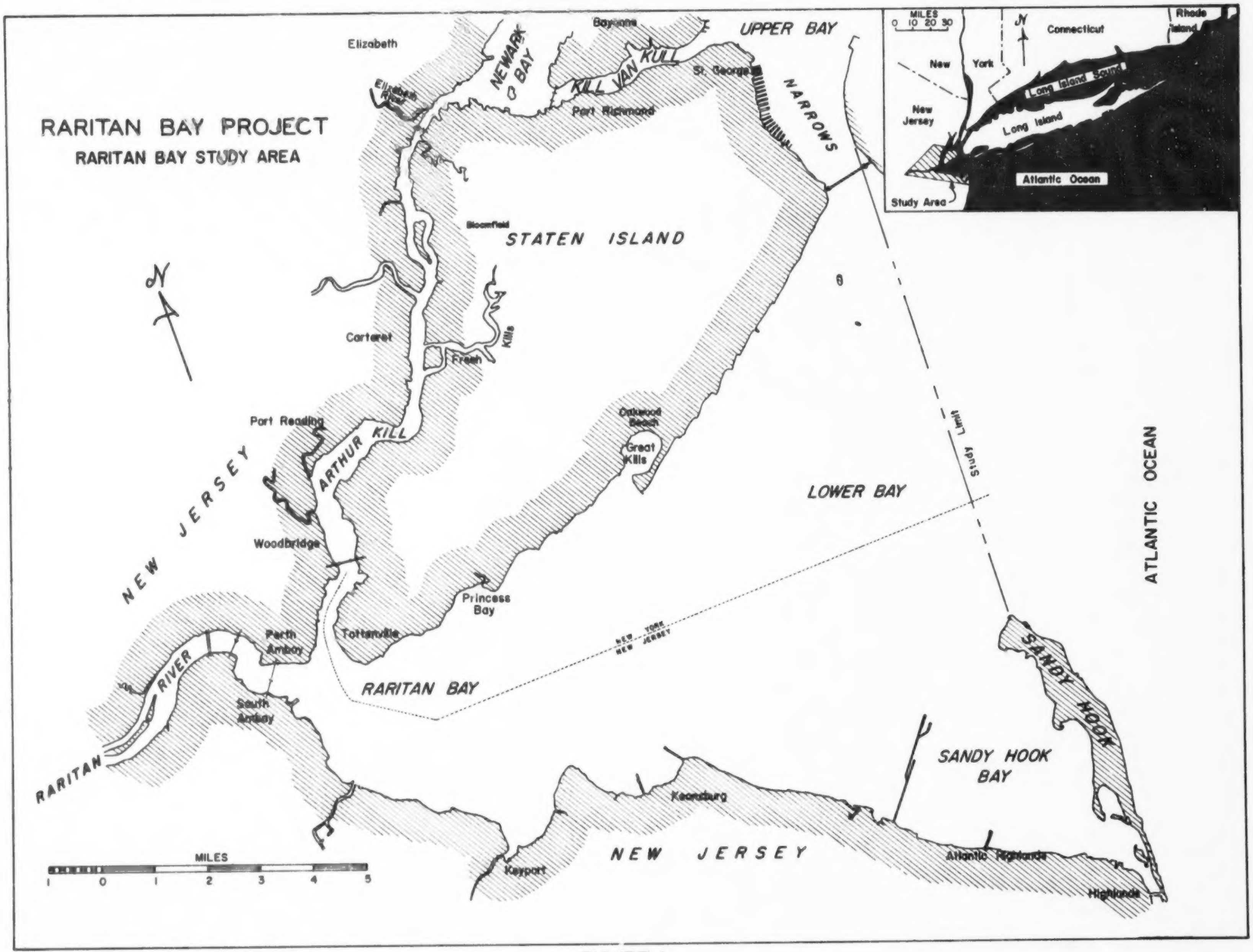
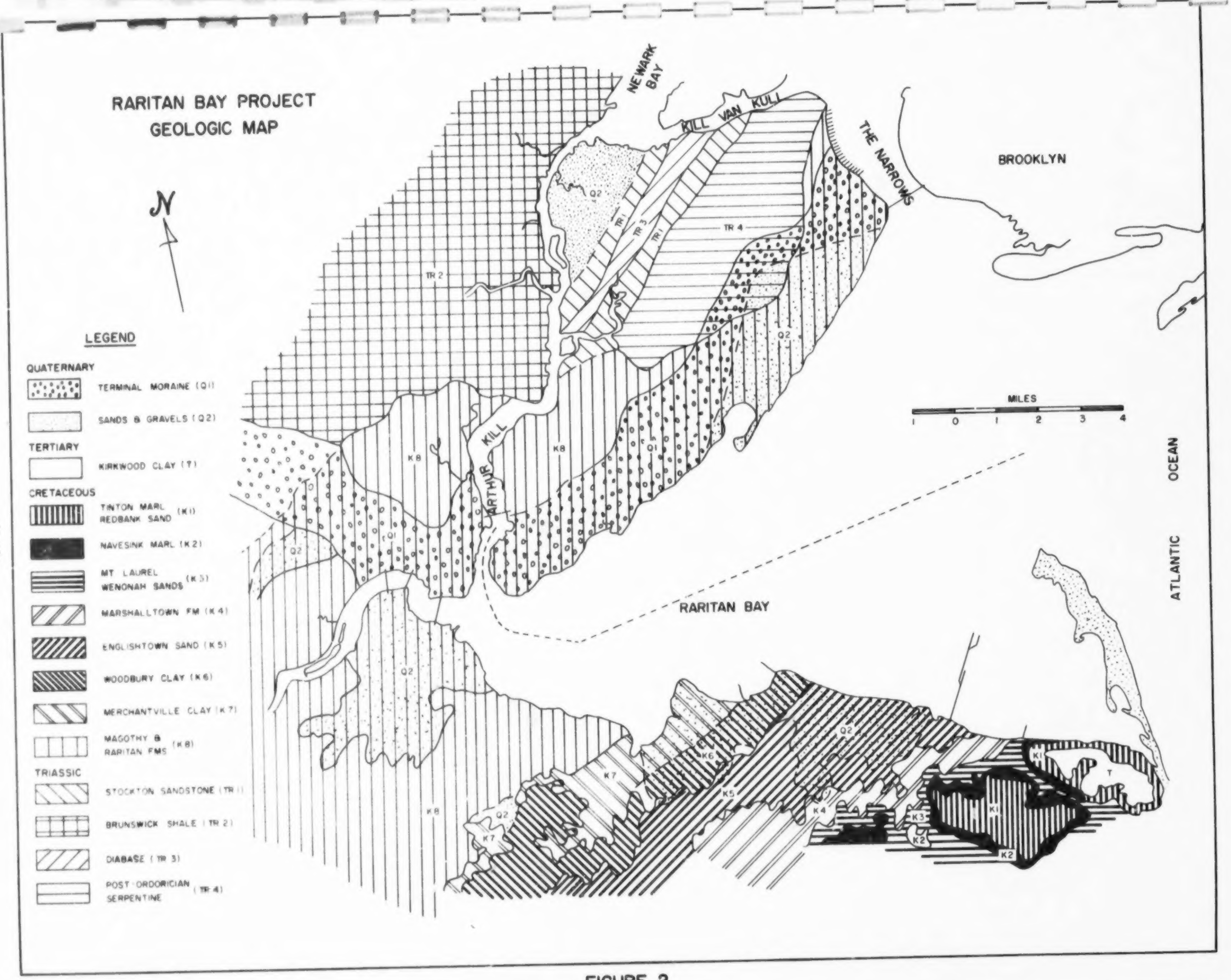

RARITAN BAY PROJECT
RARITAN BAY STUDY AREA
Elizabeth
Elizabeth River
NEWARK BAY
Bayonne
KILL VAN KULL
Port Richmond
St. George
UPPER BAY
NARROWS
Bloomfield
STATEN ISLAND
N
Carteret
Fresh Kills
Port Reading
ARTHUR KILL
NEW JERSEY
Woodbridge
Oakwood Beach
Great Kills
LOWER BAY
Study Limit
ATLANTIC OCEAN
Princess Bay
Perth Amboy
Tottenville
NEW YORK
NEW JERSEY
RARITAN BAY
RARITAN RIVER
South Amboy
SANDY HOOK
SANDY HOOK BAY
Keansburg
NEW JERSEY
Keyport
Atlantic Highlands
Highlands
MILES
1 0 1 2 3 4 5
MILES
0 10 20 30
N
Connecticut
Rhode Island
New York
New Jersey
Long Island Sound
Long Island
Atlantic Ocean
Study Area

FIGURE I

GPO 955-949



RARITAN BAY PROJECT
GEOLOGIC MAP

N
LEGEND
QUATERNARY
TERMINAL MORAINE (Q1)
SANDS & GRAVELS (Q2)
TERTIARY
KIRKWOOD CLAY (T)
CRETACEOUS
TINTON MARL REDBANK SAND (K1)
NAVESINK MARL (K2)
MT LAUREL WENONAH SANDS (K3)
MARSHALLTOWN FM (K4)
ENGLISHTOWN SAND (K5)
WOODBURY CLAY (K6)
MERCHANTVILLE CLAY (K7)
MAGOTHY & RARITAN FMS (K8)
TRIASSIC
STOCKTON SANDSTONE (TR 1)
BRUNSWICK SHALE (TR 2)
DIABASE (TR 3)
POST-ORDORICIAN SERPENTINE (TR 4)
NEWARK BAY
KILL VAN KULL
THE NARROWS
BROOKLYN
ARTHUR KILL
RARITAN BAY
ATLANTIC OCEAN
MILES
1 0 1 2 3 4
TR 1
TR 2
TR 3
TR 4
Q1
Q2
K1
K2
K3
K4
K5
K6
K7
K8
T

FIGURE 2

STUDY PROCEDURES

Specific sampling and analysis for this investigation was conducted during July and August 1963. In addition, results of general sampling for chloride, salinity, temperature and wind directions, as described in Volume I, were used for this report.

Field stations used for this investigation were these established by the Project for chemical and bacteriological studies of the Bay. The stations are shown in Figure 3. Stations 31, 64, and the shore stations (600 and 700 series) were not sampled during this geology study.

SAMPLE COLLECTION

Bottom samples were obtained with a Petersen Grab Sampler. Contents of the sampler were emptied into a large enamel pan, where the sample was examined for color, stratification, texture, mass properties and unusual odor. A quart of sediment was preserved in 10% formalin for later mechanical and paleontological analyses in the Project laboratory. When stratification was noted in the sample, at least 50 ml was taken from each layer and preserved in small containers for later analysis. At the time of each bottom sampling the temperature, salinity and pH were taken of water at 5' below the surface and 5' above the bottom.

MECHANICAL ANALYSIS

Samples were analyzed for size distribution by passing through a series of graded sieves, with the fraction retained by each sieve weighed. After weight of each fraction was measured or calculated, the weight of all fractions were added to obtain the total sediment weight in each sample, and the percentage of total weight represented by each fraction was determined. The cumulative weight percent was then plotted on a cumulative curve with sediment size as the abscissa and cumulative weight percent as the ordinate.

From the cumulative curve, three size measurements were directly determined, the median and the first and third quartiles. The median size is the diameter, of the sediment particles at the midpoint in the cumulative curve, while the first quartile (Q_1) and third quartile (Q_3) sizes are the diameters of sediment particles at the 25 and 75 percent points respectively on the cumulative curve.

The sorting coefficient, S_o, was then calculated from the relationship: $S_o = \sqrt{Q_1/Q_3}$, where Q_1 is always the coarser quartile. The sorting coefficient provides an index to the uniformity of sediments.

Bulk density was determined by dividing the mass of each sample, as determined in the sieve analysis, by the volume of sample, generally one liter. Because of compaction, the volume of the one liter sample collected actually varied by about 5 percent, so that density determinations were marked by an error of this magnitude. However, since densities were generally either over 1.0 kilogram per liter, or less than 0.5 kg/l, the error is relatively insignificant.

CHEMICAL AND MINERALOGICAL ANALYSES

Chemical analyses of the sediments included water content, organic matter content, and carbonate content. In addition the minerology of the samples was determined to classify the sediment.

Water and organic content were analyzed chemically, by weight. A sample was weighed, dried, washed to remove dissolved salts, redried and weighed, with the difference in initial and final weight representing the water content. The dry sediment was then washed with hydrogen peroxide to remove organic matter by oxidation and the organic content determined by loss in weight.

Microscopic point count analyses were performed to determine the weight of organic debris, carbonate content and minerology.

MOLLUSK DETERMINATION

Approximately one quart of preserved bottom sample was screened and all organisms picked out of the coarse size fractions. Live shellfish were counted, measured and weighed. Empty shells were weighed. Only the distribution of common mollusks caught in the #5 screen was determined.

SEDIMENT DISTRIBUTION DETERMINATION

Sediment distribution studies were made for three types of particles; (1) a clastic particle introduced by natural physical processes, the mineral muscovite; (2) a clastic particle produced within the bay, the empty shells of a small clam Mulinia lateralis; (3) a clastic particle introduced by man, detrital coal. For these studies the weight of particles under consideration caught in the largest screen, was taken for all stations and plotted on a chart of the bay. The same process was then repeated for all sieves down to the smallest in which the particles under study were retained. The distribution of particles caught in the larger screens was compared to that for the smaller screens to determine origin and distribution of the sediment particles.

The muscovite particle distribution was done by point count percent. To find point count percent, a large number of mineral grains are counted and the grain minerology determined. The number of muscovite grains per 100 grain of sediment is then calculated. This procedure was done for particles retained in the #20, #40 and #100 sieves at each station.

Detrital coal caught in the #5 sieve was weighed directly. The amount caught in the #20, #40, and #100 sieves was calculated by volume percentage timer density ratio, and expressed in grams of coal per liter of sediment retained for each sieve size.

Mollusk shell determination was made by measuring and comparing total weight of shells at each station.

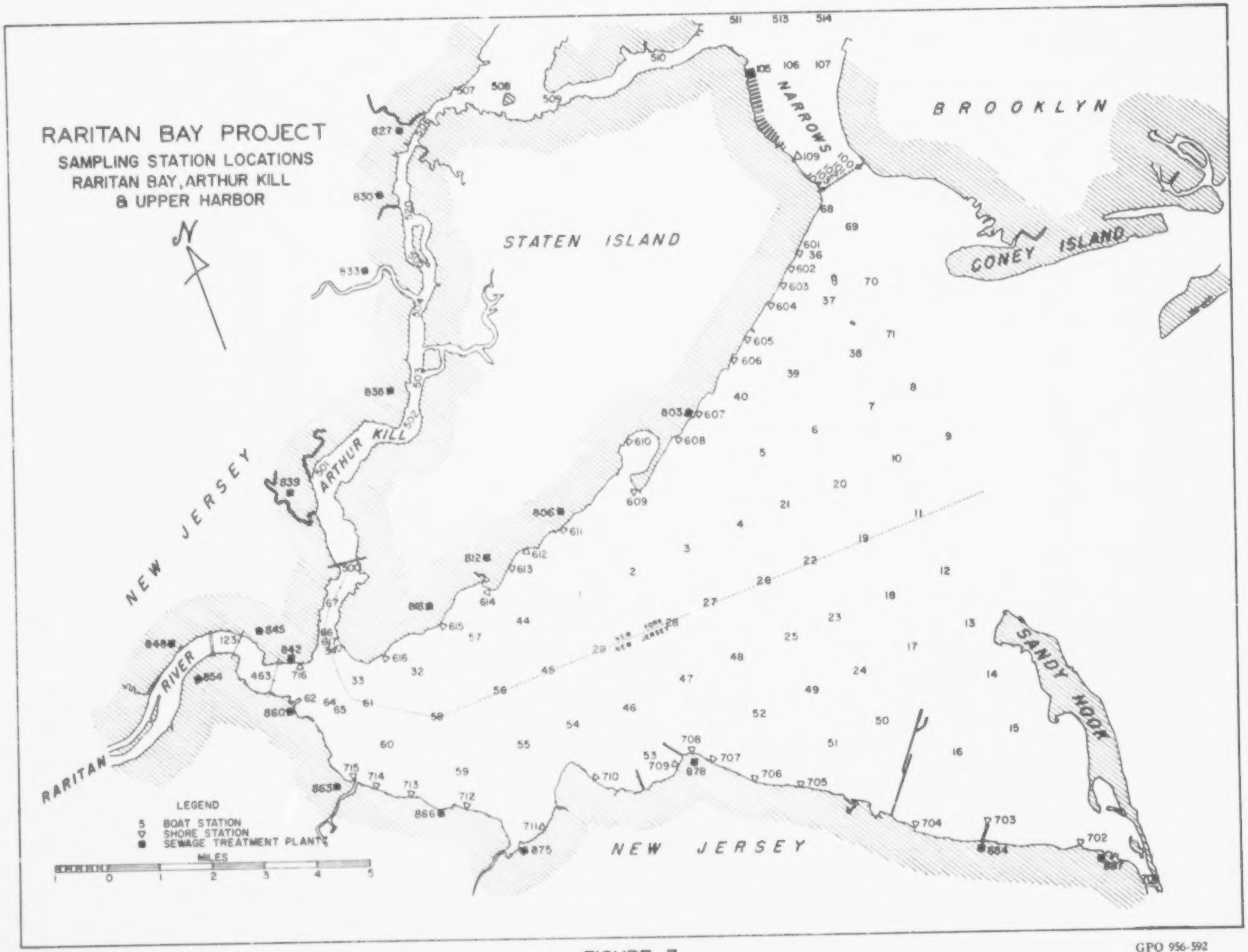

RARITAN BAY PROJECT
SAMPLING STATION LOCATIONS
RARITAN BAY, ARTHUR KILL
& UPPER HARBOR
N
STATEN ISLAND
BROOKLYN
CONEY ISLAND
NARROWS
SANDY HOOK
NEW JERSEY
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW YORK
NEW JERSEY
LEGEND
5 BOAT STATION
▽ SHORE STATION
■ SEWAGE TREATMENT PLANT
MILES
1
0
1
2
3
4
5
511
513
514
106
106
107
109
510
509
508
507
827
830
833
836
839
503
502
501
500
845
842
848
854
860
863
866
875
878
884
887
123
463
716
62
64
65
61
66
67
68
69
70
71
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
803
806
812
818
36
37
38
39
40
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
32
33
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
702
703
704
705
706
707
708
709
710
711
712
713
714
715

FIGURE 3

GPO 956-592

RESULTS

WATER MASSES

Chlorinity: Plots of chlorinity determinations performed by the Project were made to define the limits of water masses in the Bay. To eliminate effects of other variables, limits were imposed as follows: (1) Temperature, ±1.5°C; (2) Wind directions, one major compass point ± 45°; (3) Tidal cycle, and last half of one cycle to the first half of the next; (4) Time of year, for all stations restricted to a period of five weeks.

Figure 4 shows the average chloride content for the period June to December 1962 at 5 foot depth, and indicates that there is: (1) a mass of relatively high chlorinity water (13.8 parts per thousand or greater) extending from Seguine Point to Sandy Hook; (2) a more relatively low chlorinity water extending along the southeast part of the bay; and (3) an intermediate zone between these two masses which extends southeast to Highlands. Figure 5 shows the average chloride content 5 feet from the bottom for the same period.

Figures 6, 7 and 8 show average chloride concentrations at 5 feet depths in May 1963, July 1962 and October 1962 respectively. These indicate the same pattern of water mass distribution noted in Figure 4, but with these additions: (1) In Sandy Hook Bay, a tongue of high chlorinity water projects southward just west of Sandy Hook. Lower chlorinity water appears west of this tongue (Figure 7); (2) The high chlorinity water projecting into Lower Bay is divided into two lobes. The major lobe extends westward from the mouth of the bay toward Seguine Point, and a smaller lobe projects landward toward New Dorp on Staten Island (Figures 6 and 7); (3) A mass of low chlorinity water projects northeastward from the area between Keansburg and Shoal Harbor, on the New Jersey shore (Figure 8).

Figures 9 and 10 show positions of deepwater masses in June-July 1962 and October 1962 respectively. A comparison of these with previous figures show that the position of deep water masses corresponds closely to that of shallow water masses for October 1962 and July 1962. The displacement noted for the period June-December 1962, Figures 4 and 5, may be due to increased fresh water run off during the period. The less dense fresh water would override the heavier sea water, moving the surface water mass eastward of the bottom mass.

In a shallow bay, such as Raritan Bay, wave motion normally has an important effect on distribution of water masses. The predominant incoming waves at the entrance to New York Harbor are from the east and northeast. With a west wind, the main tongue of higher chlorinity water was closer to the Staten Island shore. However, stream flow entering the bay from the Raritan River and other tributary streams was not a controlled variable during the study. Hence, insufficient data are available to determine how much of this mass location is attributable to winds as opposed to increased fresh water run-off.

SEDIMENT BODIES

Sediment Size: Size analysis showed four distinct sediment bodies in Raritan Bay, two of which are sands and two of which are predominantly silts, referred to here as "muds". The location of these four bodies are shown in Figure 11.

A prominent sand body, here called the Keansburg sands, occurs north of Keansburg, at Stations 44, 45, 46, 51, 52, 53, 54 and 55. These sands are fairly coarse, averaging 300 microns in diameter. The median size increases westward to the area north of Keyport where the body ends abruptly. The boundary of this body roughly parallels the New Jersey shoreline between Leonardo and Keyport.

The other sand body, designated the Lower Bay Sands, occupies the northeastern three quarters of Lower New York Bay. These sands are found east of Stations 2, 26, 18, 13 and 24 and extend to the channels marking the eastern end of the Raritan Bay area. The average median diameter of these sands is 250 microns, increasing seaward.

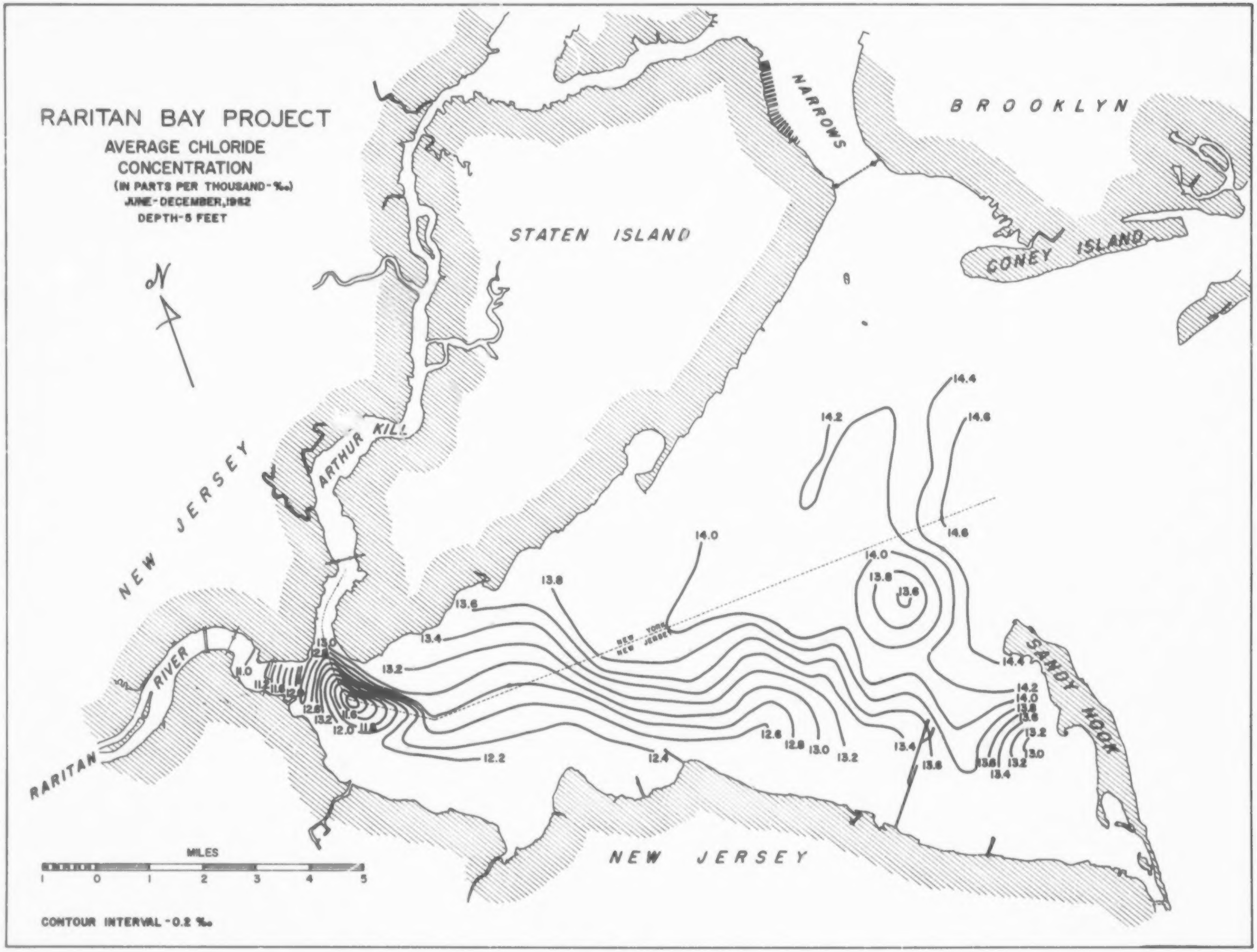
West of Sandy Hook, the sediment consists of coarse to medium silts ranging in size between 15 and 60 microns. These Sandy Hook Bay muds are found at Stations 1, 14, 15, 16, 17, 27, 28, 29, 48 and 49 and extend from Sandy Hook toward Seguine Point.

The predominant sediments in Raritan Bay proper are coarse silts, ranging in size between 20 and 60 microns. This sediment, referred to here as West Raritan Bay muds, are found west of an imaginary line between Keyport and Seguine Point.

For many of the stations both the entire sample and the clastic particles were analyzed. Figure 12 presents the median size for the entire sample, while that for the clastic particles are shown in Figure 13. The difference between the median sizes for these two determinations is due to organic matter and shells in the entire sample.

Sorting coefficients are closely related to sediment types, with lower values indicating greater uniformity of grain size. The sorting coefficients for entire samples are plotted in Figure 14. Sorting coefficients for clastic particles are shown in Figure 15. The sands are better sorted than the silts. For the entire sample, the Keansburg and Lower Bay Sands generally show a sorting coefficient less than 2.0 while the muds show coefficients greater than 2.0 often greater than 3.0. For the clastic particles only, the sands showed a coefficient of less than 1.5, while the muds were greater than 1.5. Clastic particle sorting coefficients of the Keansburg Sands are strikingly similar, with nearly all ranging from 1.2 to 1.3. The sorting of the Lower Bay sands was less consistent.

The bulk density of sediments is shown in Figure 16. The sands were relatively dense, over 1.0 kg/l, while the muds showed a consistently lower density, generally less than 0.5 kg/l.



RARITAN BAY PROJECT

AVERAGE CHLORIDE CONCENTRATION

(IN PARTS PER THOUSAND - ‰)

JUNE - DECEMBER, 1962

DEPTH - 5 FEET

N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW JERSEY
SANDY HOOK
NEW YORK
NEW JERSEY
11.0
11.2
11.6
12.0
12.8
13.0
12.8
13.2
11.6
12.0
11.8
13.2
13.4
13.6
13.8
14.0
12.2
12.4
12.6
12.8
13.0
13.2
13.4
13.6
14.2
14.4
14.6
14.6
14.0
13.8
13.6
14.4
14.2
14.0
13.8
13.6
13.2
13.0
13.2
13.4
13.6
MILES
1
0
1
2
3
4
5
CONTOUR INTERVAL - 0.2 ‰

FIGURE 4

GPO 956-592

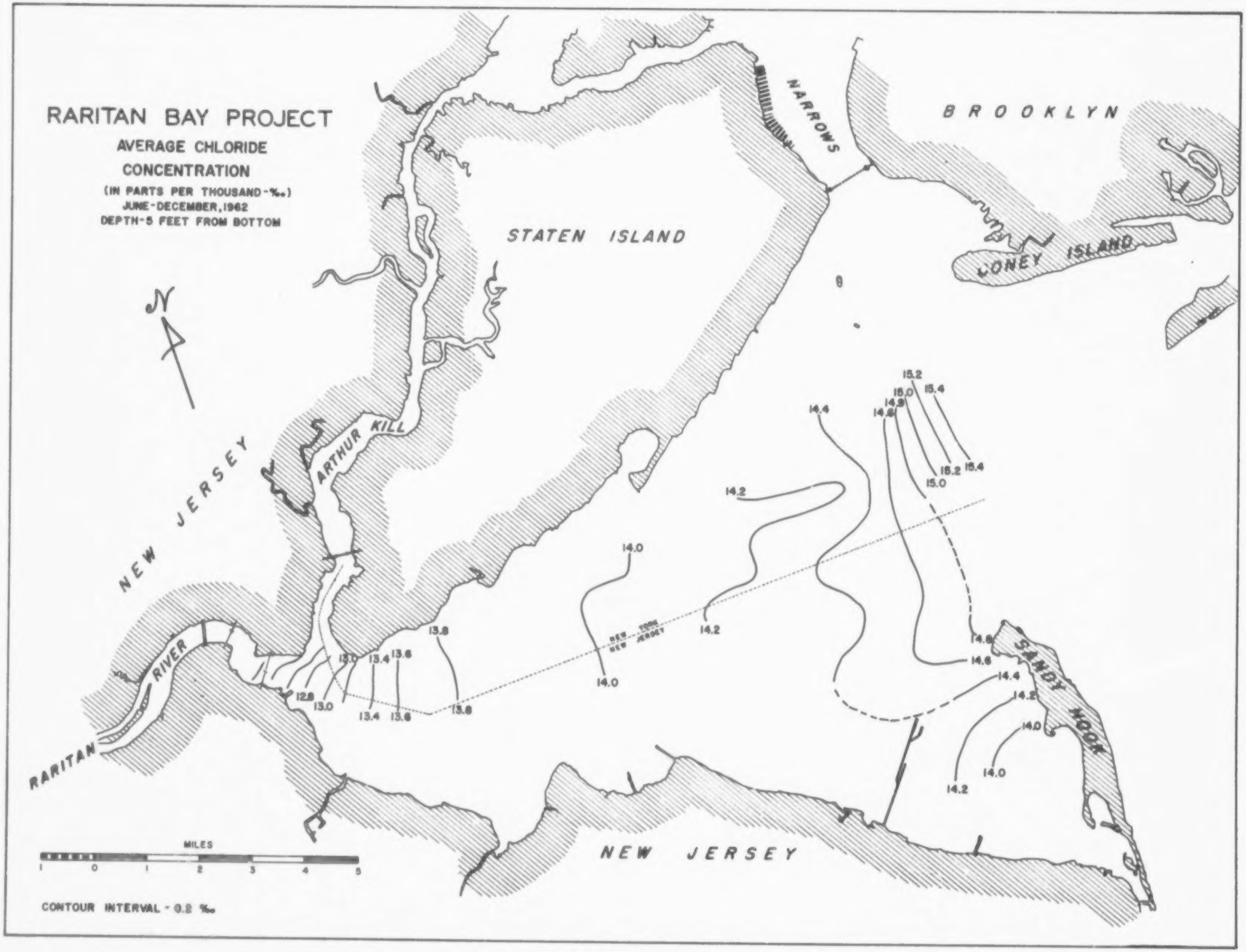

RARITAN BAY PROJECT
AVERAGE CHLORIDE
CONCENTRATION
(IN PARTS PER THOUSAND-‰)
JUNE-DECEMBER, 1962
DEPTH-5 FEET FROM BOTTOM
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW JERSEY
SANDY HOOK
NEW YORK
NEW JERSEY
12.8
13.0
13.0
13.4
13.4
13.6
13.6
13.8
13.8
14.0
14.0
14.0
14.0
14.2
14.2
14.2
14.2
14.4
14.4
14.6
14.6
14.8
15.0
15.0
15.2
15.2
15.4
15.4
MILES
1 0 1 2 3 4 5
CONTOUR INTERVAL - 0.2 ‰

FIGURE 5

GPO 956-592

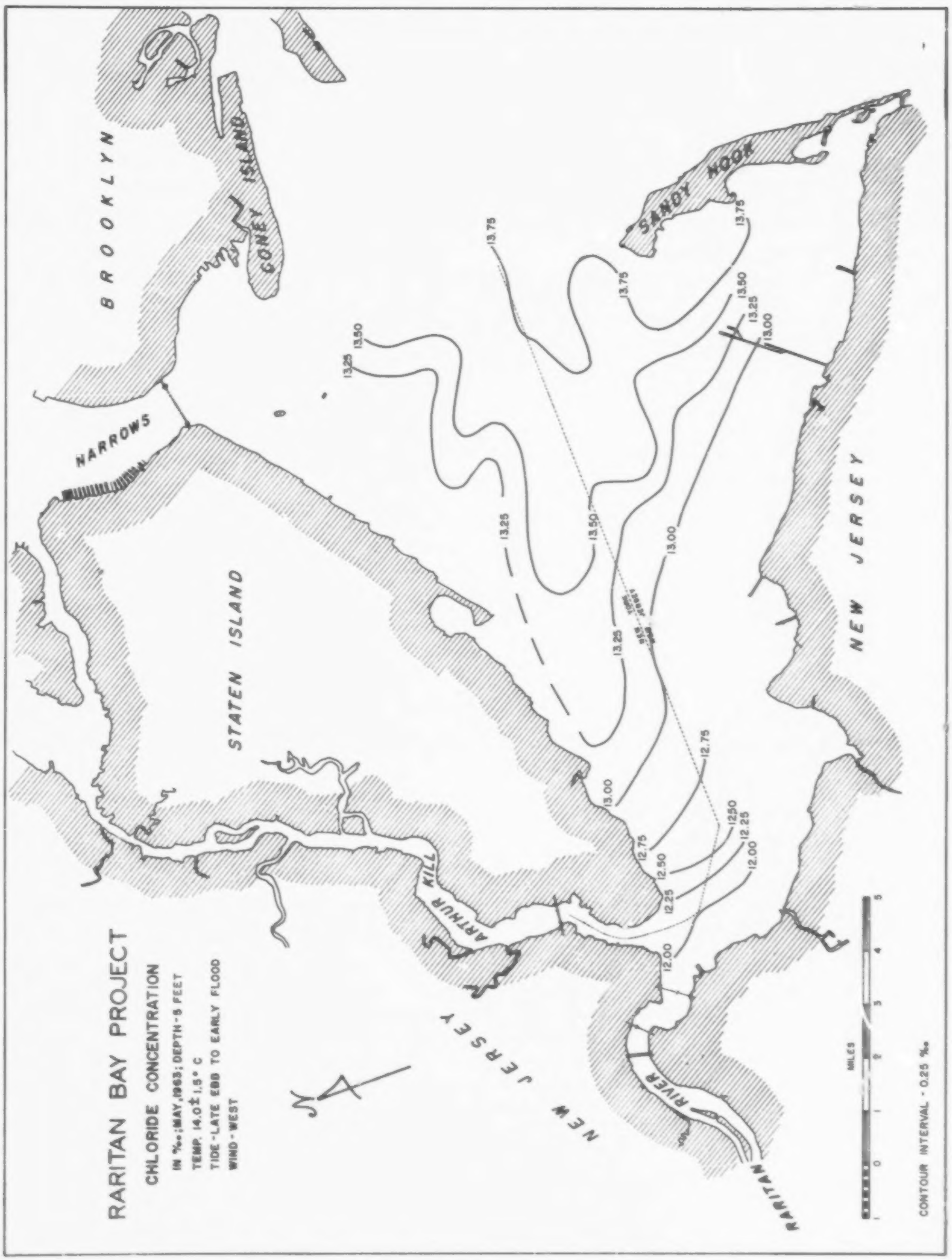
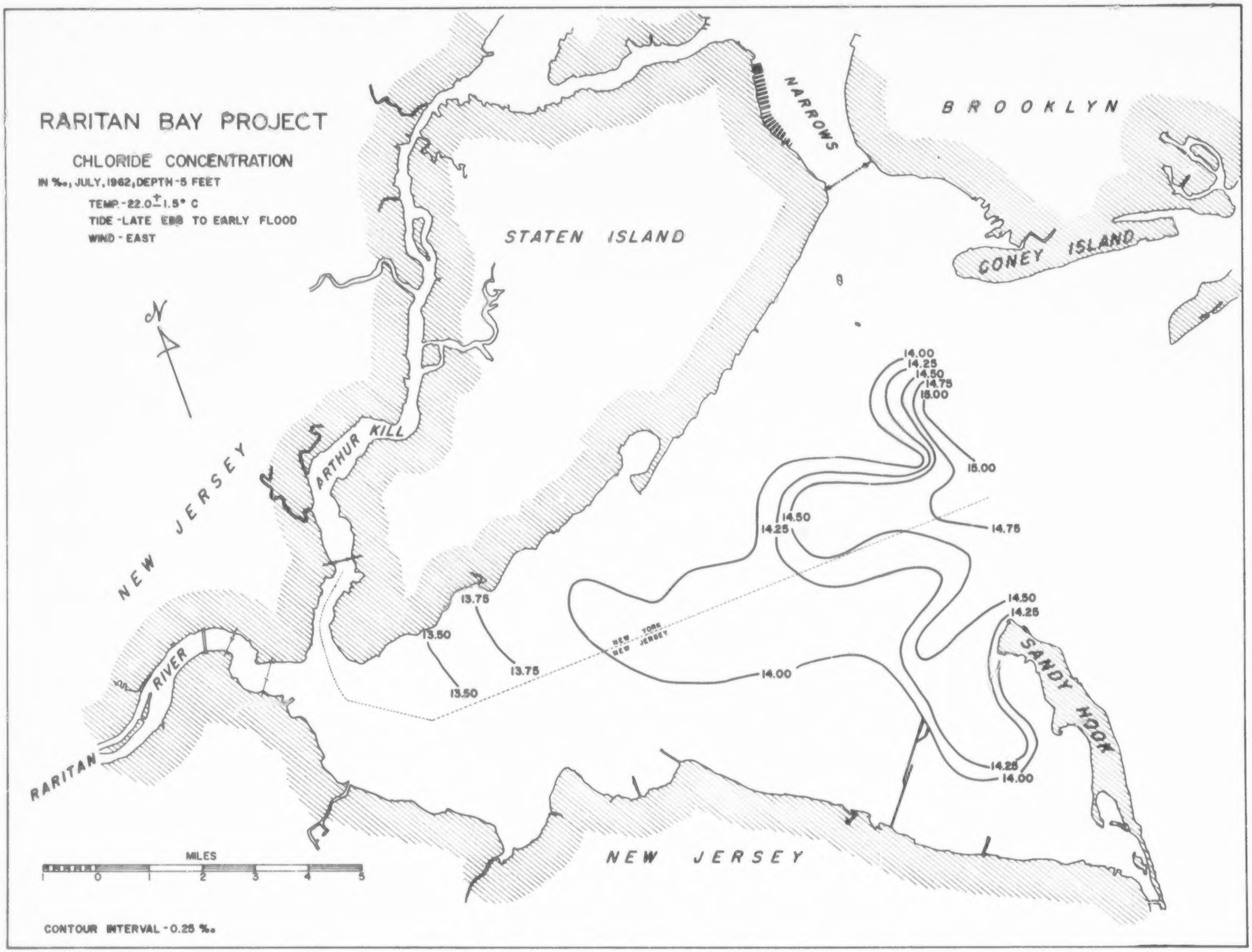

RARITAN BAY PROJECT
CHLORIDE CONCENTRATION
IN ‰; MAY, 1963; DEPTH - 5 FEET
TEMP. 14.0 ± 1.5° C
TIDE - LATE EBB TO EARLY FLOOD
WIND - WEST
BROOKLYN
CONEY ISLAND
NARROWS
STATEN ISLAND
ARTHUR KILL
NEW JERSEY
NEW JERSEY
SANDY HOOK
RARITAN RIVER
13.75
13.75
13.75
13.75
13.50
13.50
13.50
13.25
13.25
13.25
13.25
13.00
13.00
13.00
12.75
12.75
12.50
12.50
12.25
12.25
12.00
12.00
MILES
0
1
2
3
4
5
CONTOUR INTERVAL - 0.25 ‰

FIGURE 6

GPO 956-592



RARITAN BAY PROJECT

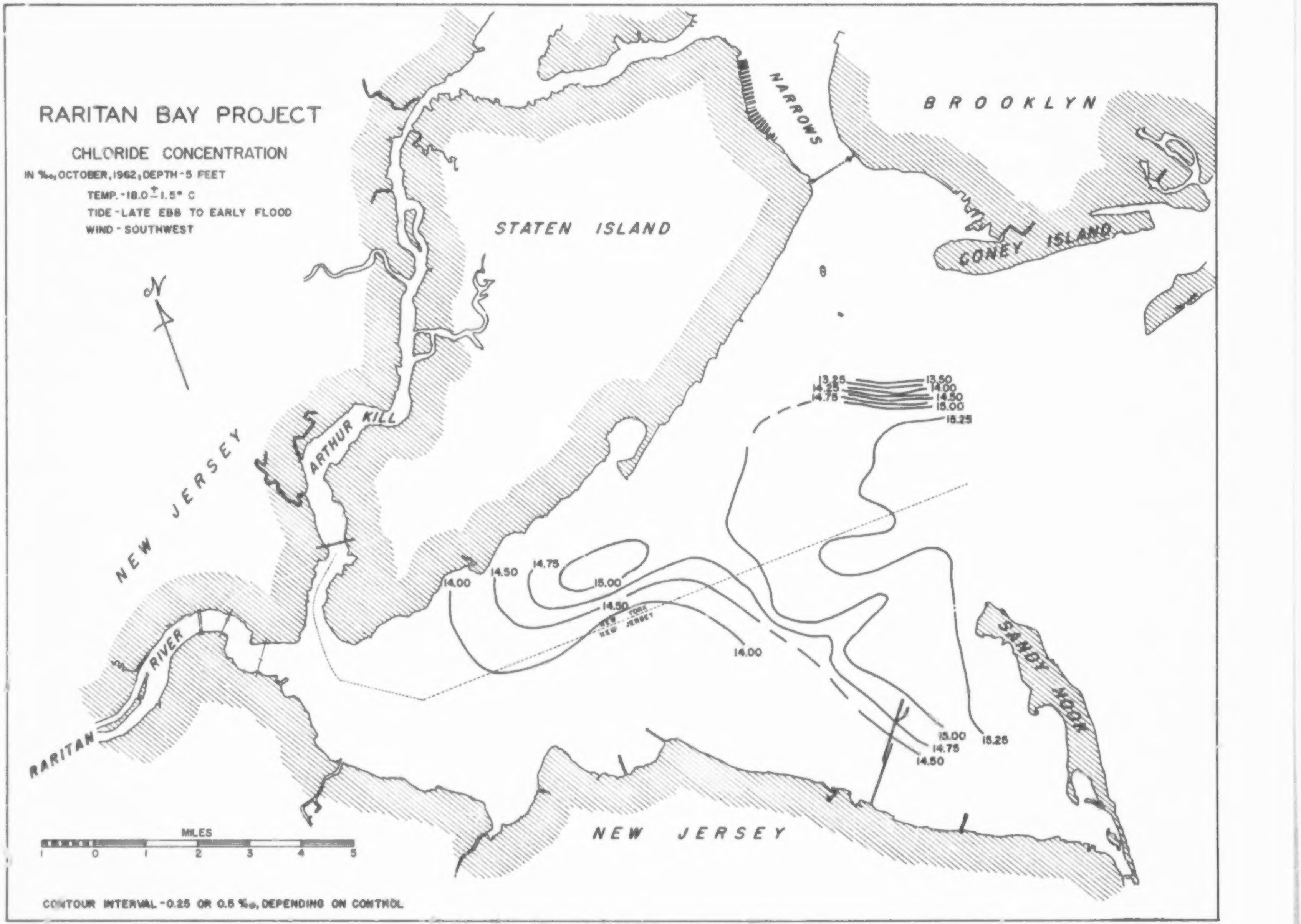
CHLORIDE CONCENTRATION
IN ‰, JULY, 1962, DEPTH-5 FEET
TEMP.-22.0 ± 1.5° C
TIDE-LATE EBB TO EARLY FLOOD
WIND-EAST

STATEN ISLAND
BROOKLYN
NARROWS
CONEY ISLAND
SANDY HOOK
NEW JERSEY
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
N
14.00
14.25
14.50
14.75
15.00
15.00
14.75
14.50
14.25
14.50
14.25
13.75
13.50
13.75
13.50
14.00
14.25
14.00
MILES
1
0
1
2
3
4
5

CONTOUR INTERVAL-0.25 ‰

FIGURE 7

GPO 956-592



RARITAN BAY PROJECT

CHLORIDE CONCENTRATION
IN ‰, OCTOBER, 1962, DEPTH - 5 FEET
TEMP. - 18.0 ± 1.5° C
TIDE - LATE EBB TO EARLY FLOOD
WIND - SOUTHWEST

CONTOUR INTERVAL - 0.25 OR 0.5 ‰, DEPENDING ON CONTROL

N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
SANDY HOOK
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW JERSEY
NEW YORK
NEW JERSEY
13.25
14.25
14.75
13.50
14.00
14.50
15.00
15.25
14.00
14.50
14.75
15.00
14.50
14.00
15.00
14.75
14.50
15.25
MILES
1
0
1
2
3
4
5

FIGURE 8

GPO 956-592

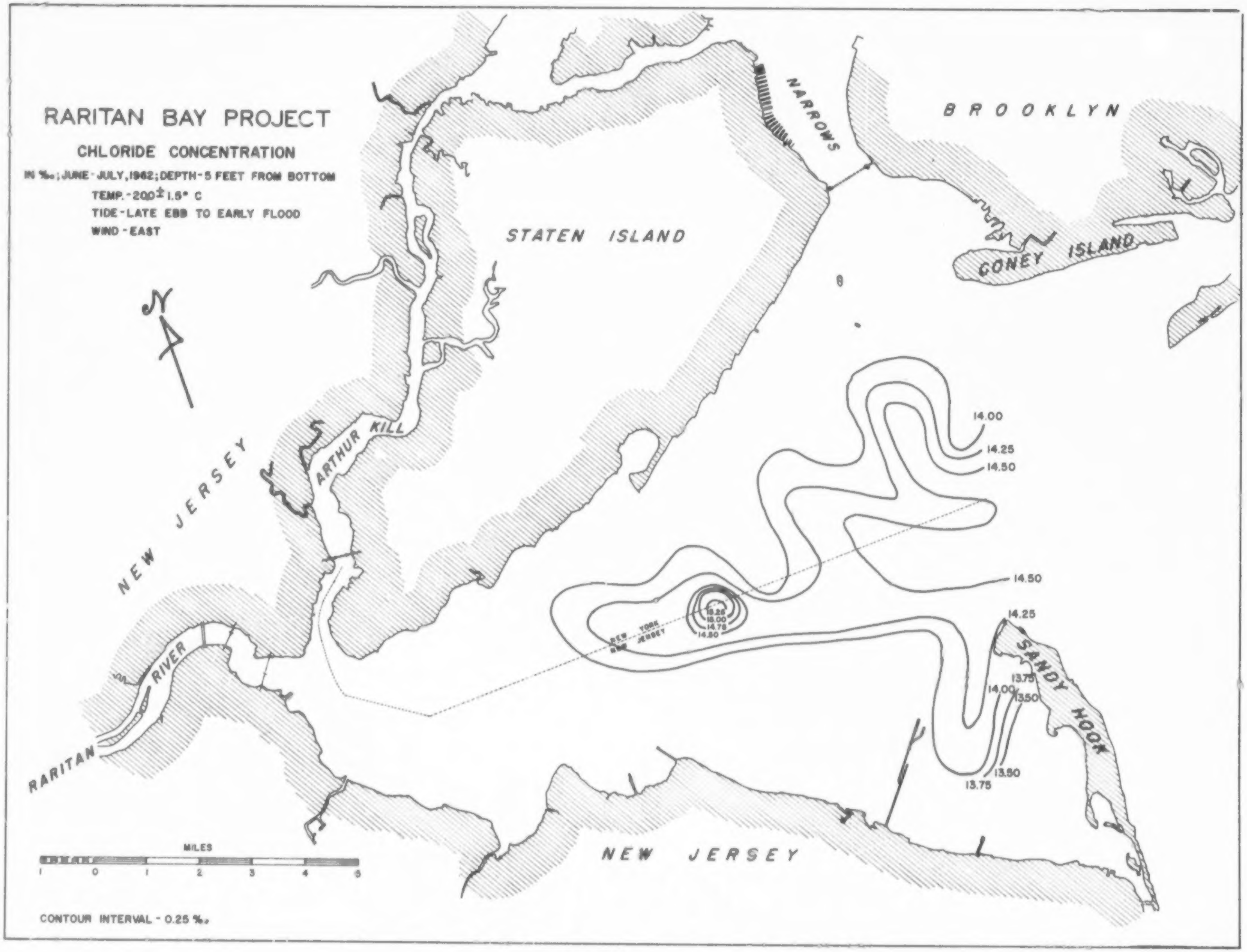

RARITAN BAY PROJECT
CHLORIDE CONCENTRATION
IN ‰; JUNE - JULY, 1962; DEPTH - 5 FEET FROM BOTTOM
TEMP. - 20.0 ± 1.5° C
TIDE - LATE EBB TO EARLY FLOOD
WIND - EAST
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
15.25
15.00
14.75
14.50
14.00
14.25
14.50
14.50
14.25
13.75
14.00
13.50
13.50
13.75
SANDY HOOK
NEW JERSEY
MILES
1
0
1
2
3
4
5
CONTOUR INTERVAL - 0.25 ‰

FIGURE 9

GPO 956-592

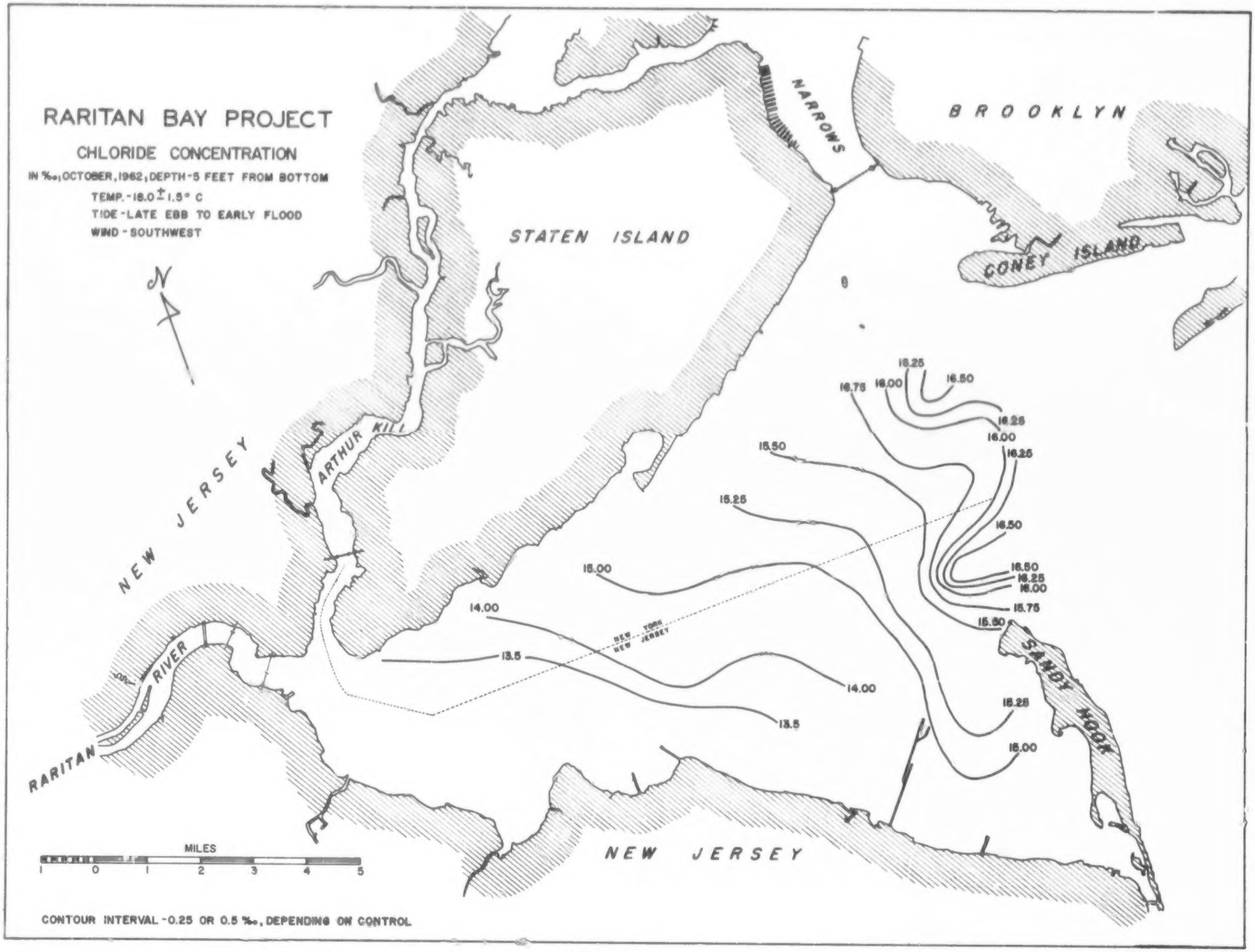
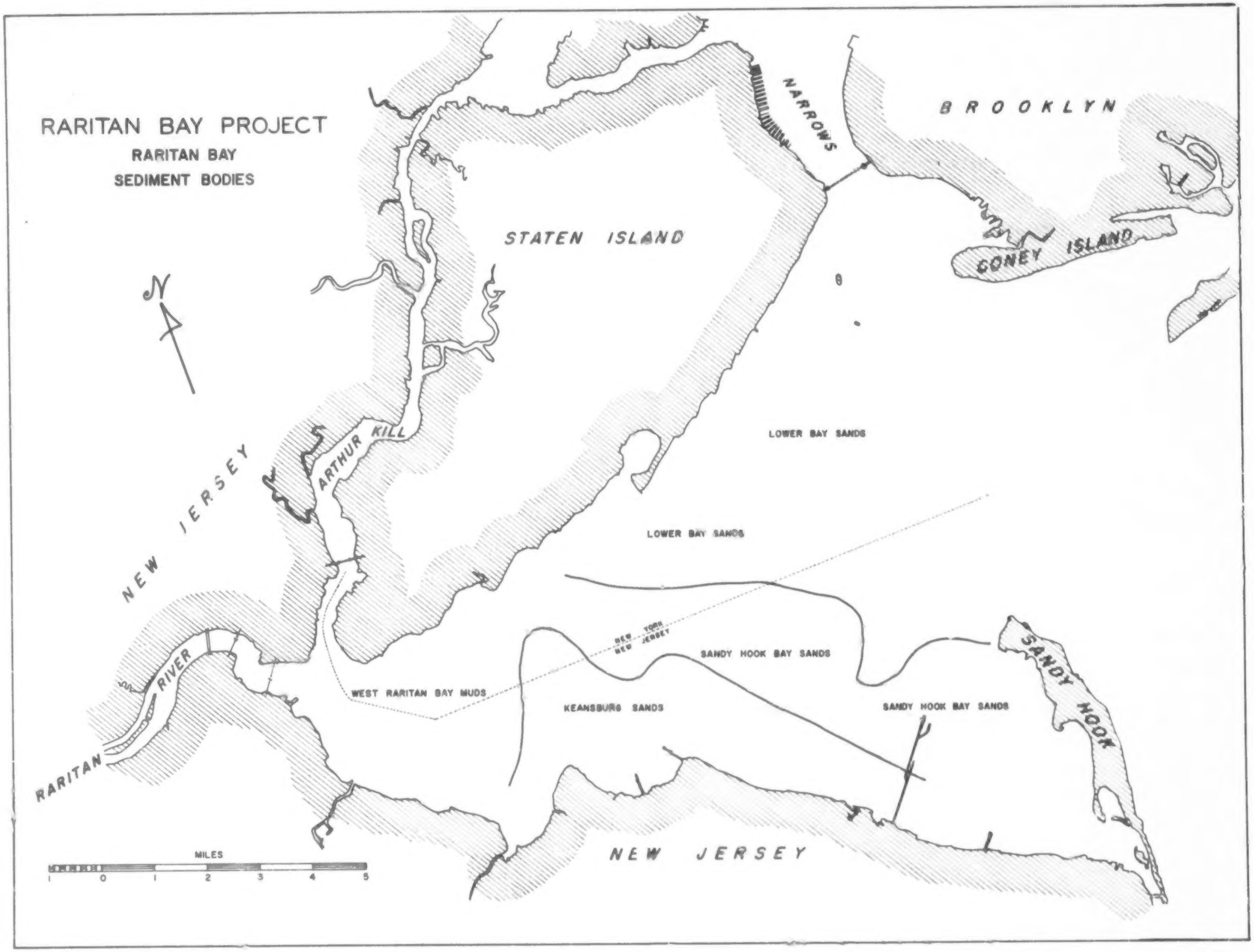

RARITAN BAY PROJECT
CHLORIDE CONCENTRATION
IN ‰, OCTOBER, 1962, DEPTH - 5 FEET FROM BOTTOM
TEMP. - 18.0 ± 1.5° C
TIDE - LATE EBB TO EARLY FLOOD
WIND - SOUTHWEST
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
SANDY HOOK
NEW JERSEY
16.25
16.50
16.75
16.00
16.25
16.00
16.25
15.50
15.25
16.50
15.00
16.50
16.25
16.00
15.75
15.50
14.00
13.5
14.00
13.5
15.25
15.00
MILES
1
0
1
2
3
4
5
CONTOUR INTERVAL - 0.25 OR 0.5 ‰, DEPENDING ON CONTROL

FIGURE 10

GPO 956-592


RARITAN BAY PROJECT
RARITAN BAY
SEDIMENT BODIES

BROOKLYN
NARROWS
CONEY ISLAND
STATEN ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
LOWER BAY SANDS
LOWER BAY SANDS
NEW YORK
NEW JERSEY
SANDY HOOK BAY SANDS
SANDY HOOK BAY SANDS
WEST RARITAN BAY MUDS
KEANSBURG SANDS
SANDY HOOK
NEW JERSEY
N
MILES
1
0
1
2
3
4
5

FIGURE II

GPO 956-592

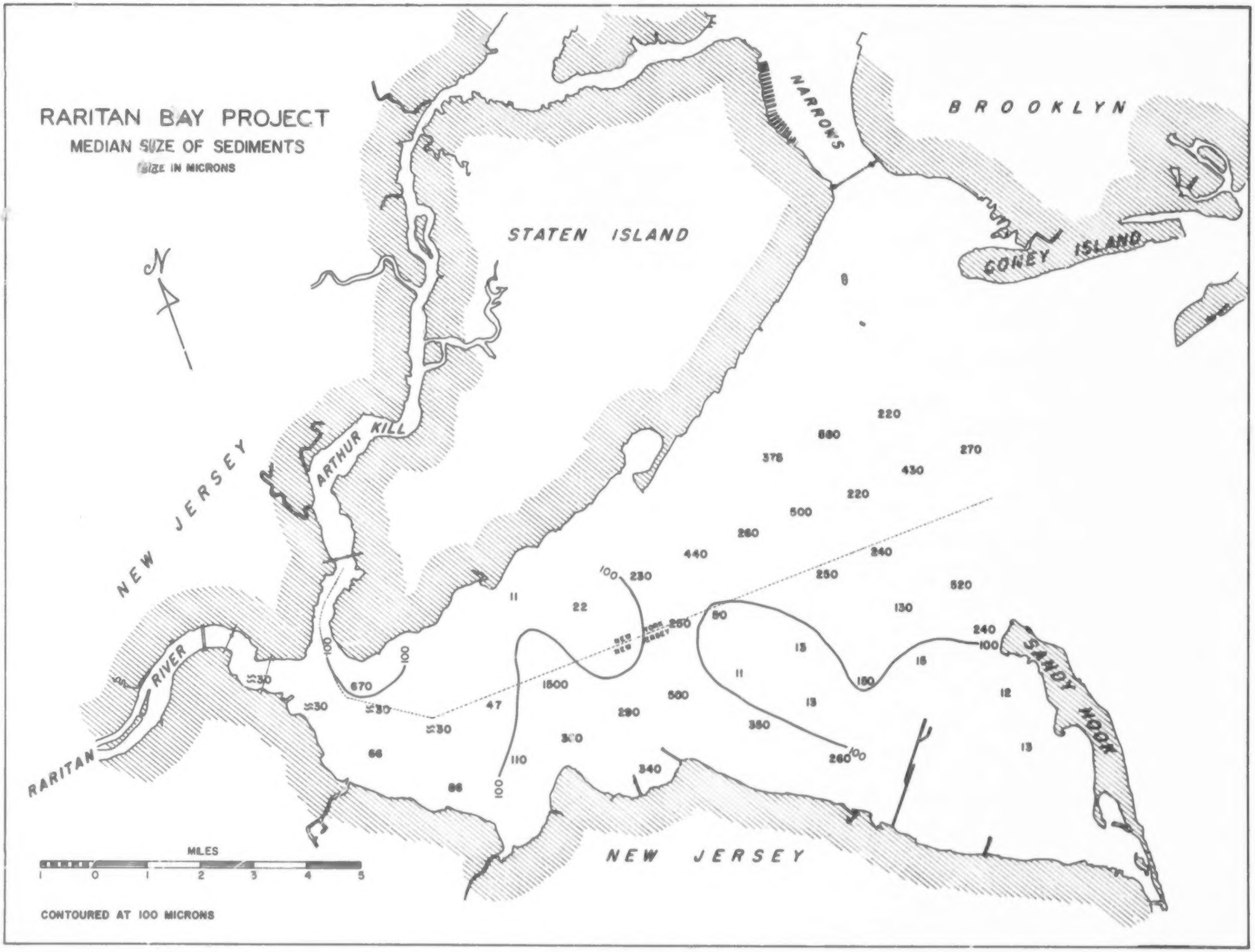

RARITAN BAY PROJECT
MEDIAN SIZE OF SEDIMENTS
SIZE IN MICRONS
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
SANDY HOOK
NEW JERSEY
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
100
230
11
22
250
80
670
≤30
≤30
≤30
≤30
47
1500
500
290
3(0
110
66
86
340
11
13
13
350
260
180
16
12
13
240
130
520
250
240
440
260
500
220
375
680
220
430
270
8
MILES
1
0
1
2
3
4
5
CONTOURED AT 100 MICRONS

FIGURE 12

GPO 956-592

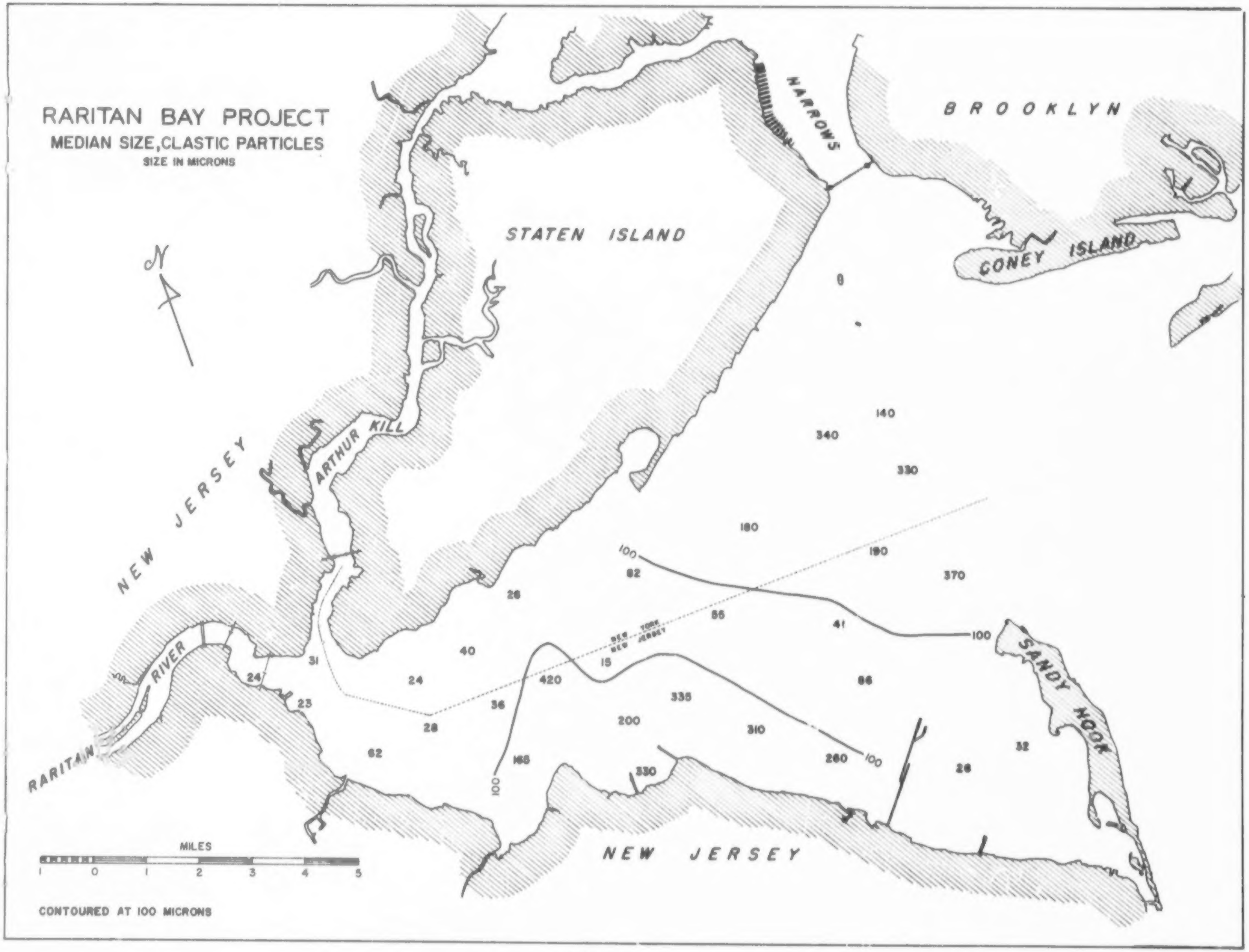

RARITAN BAY PROJECT
MEDIAN SIZE, CLASTIC PARTICLES
SIZE IN MICRONS
N
BROOKLYN
CONEY ISLAND
NARROWS
STATEN ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
SANDY HOOK
NEW JERSEY
0
140
340
330
180
190
370
100
82
26
55
41
100
40
15
24
420
86
31
36
335
24
28
200
310
23
62
165
330
260
100
26
32
100
MILES
1
0
1
2
3
4
5
CONTOURED AT 100 MICRONS

FIGURE 13

GPO 956-592

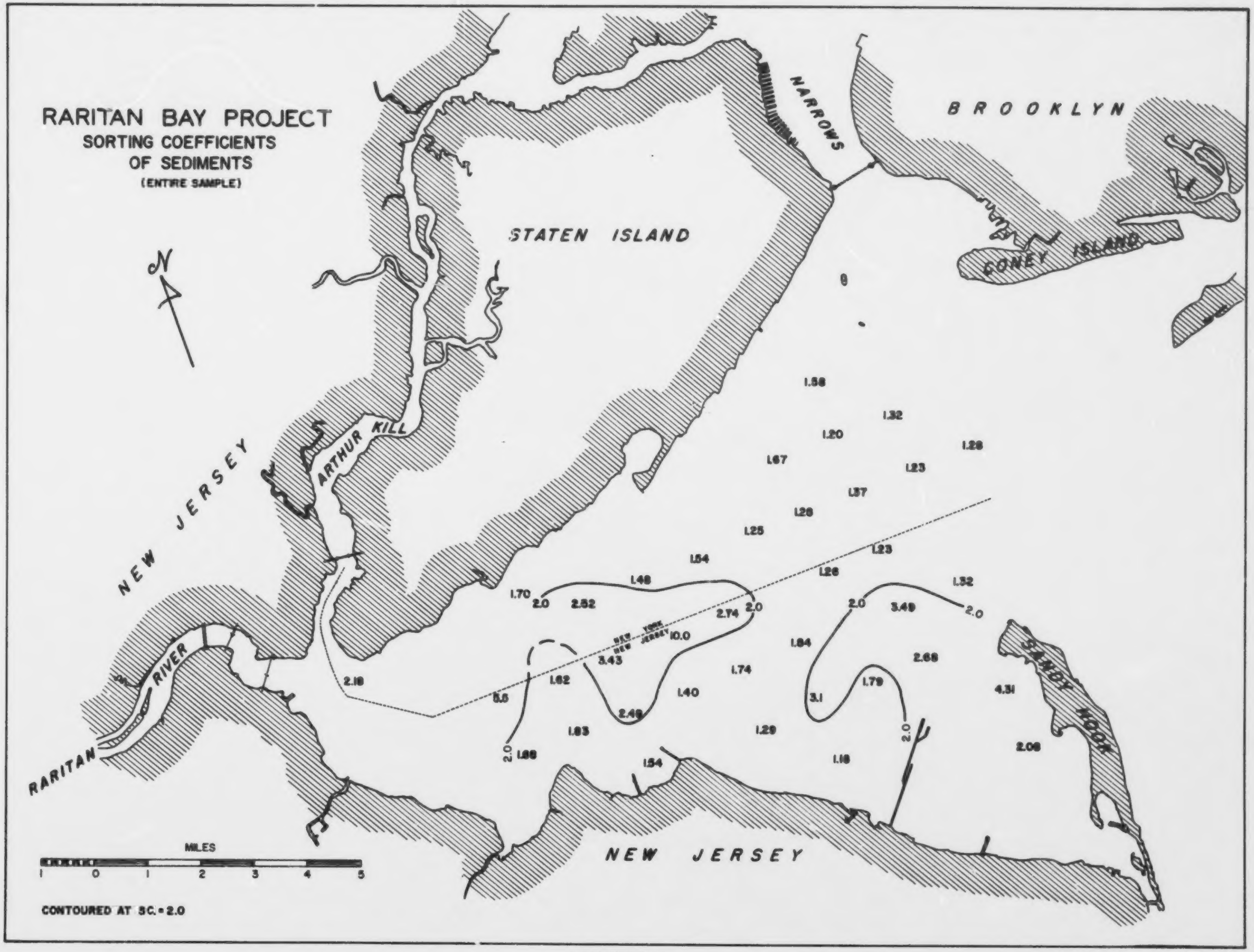
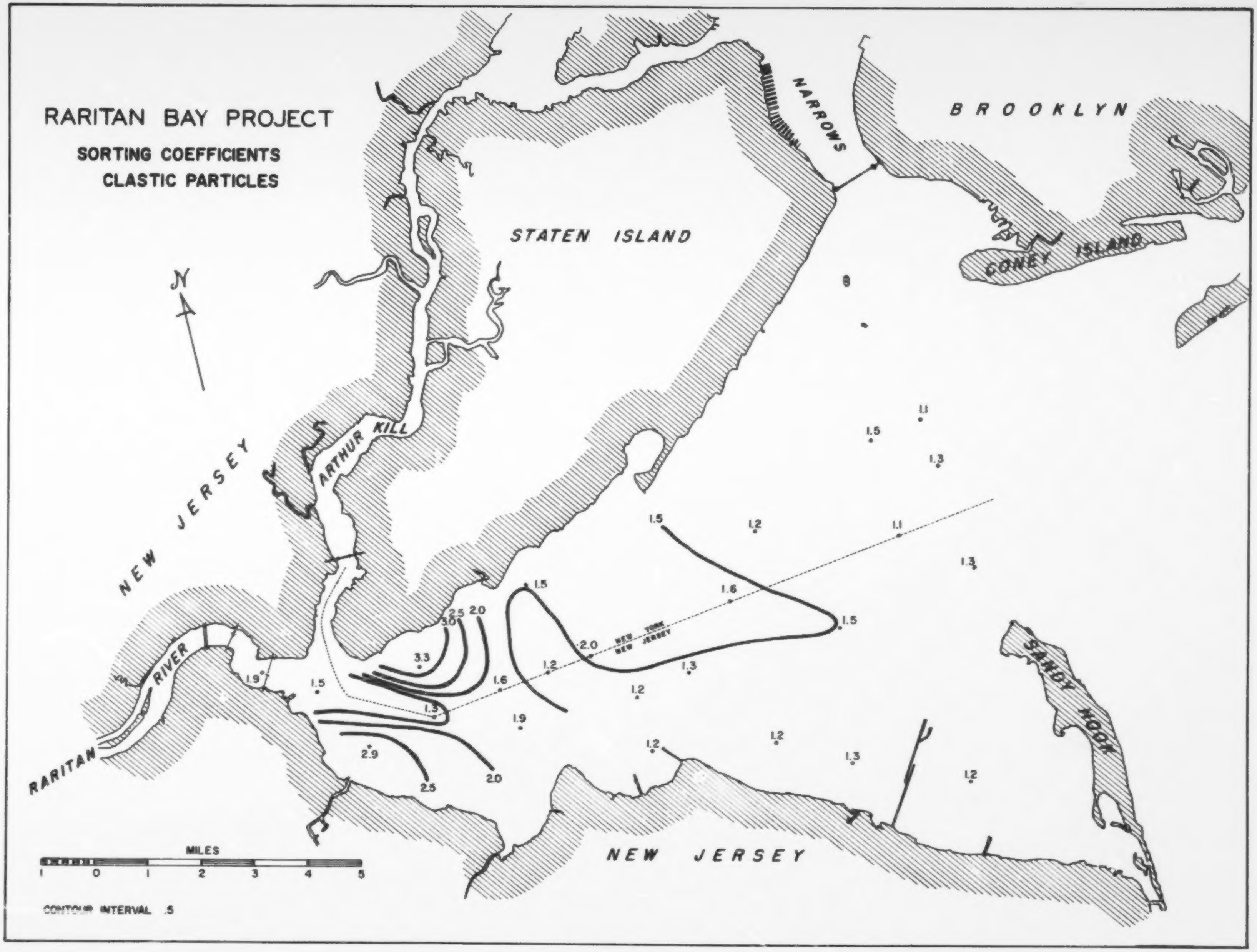

RARITAN BAY PROJECT
SORTING COEFFICIENTS
OF SEDIMENTS
(ENTIRE SAMPLE)
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN
RIVER
SANDY HOOK
NEW JERSEY
NEW YORK
NEW JERSEY
1.58
1.32
1.20
1.28
1.67
1.23
1.37
1.28
1.25
1.23
1.54
1.26
1.32
1.48
1.70
2.0
2.52
2.74
2.0
2.0
3.49
2.0
10.0
1.84
2.68
3.43
1.74
1.62
1.79
4.31
5.5
1.40
3.1
2.18
2.49
1.83
1.29
2.0
2.0
1.88
1.54
1.18
2.08
MILES
1 0 1 2 3 4 5
CONTOURED AT SC. = 2.0

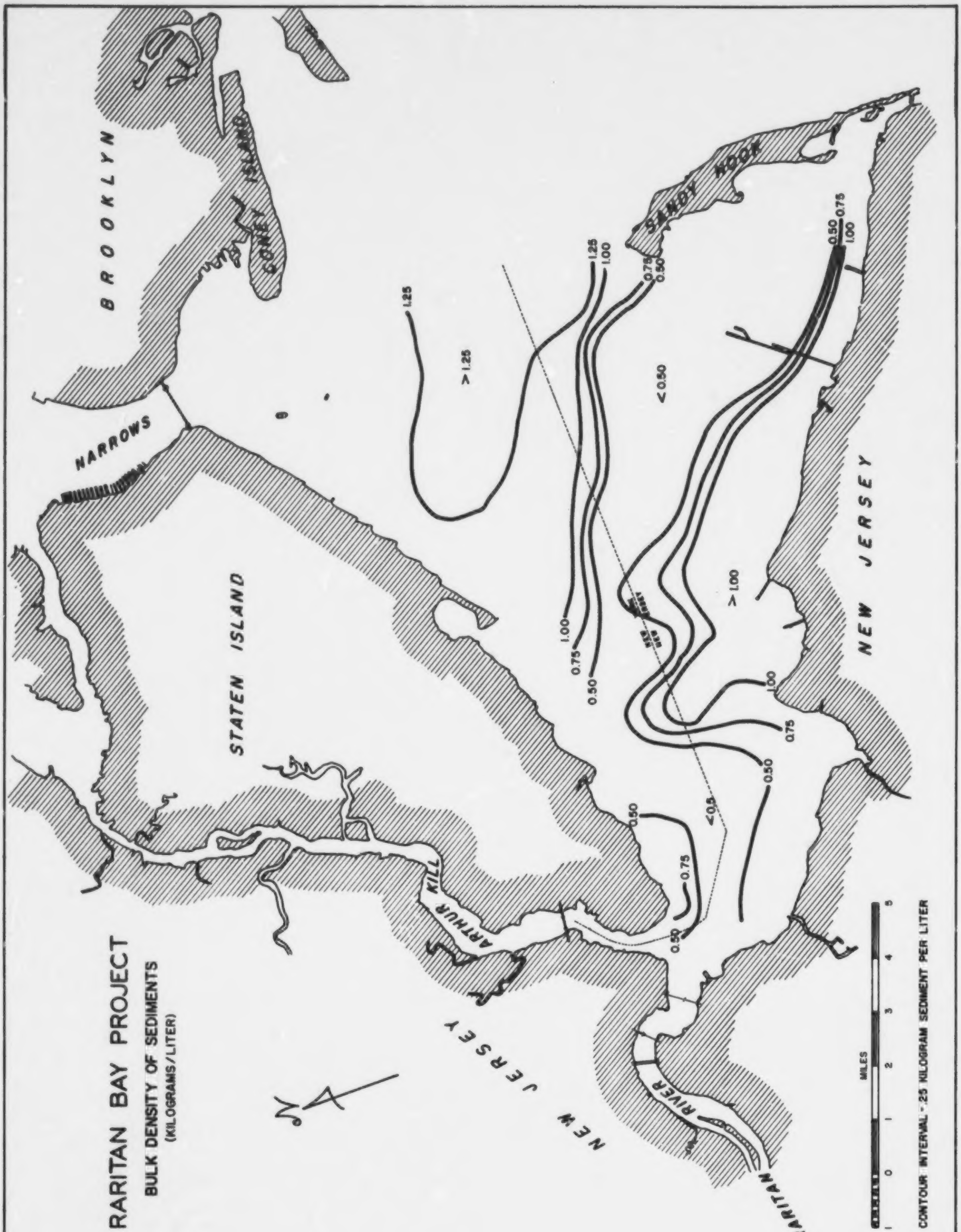
FIGURE 14

GPO 956-592


RARITAN BAY PROJECT
SORTING COEFFICIENTS
CLASTIC PARTICLES

BROOKLYN
NARROWS
CONEY ISLAND
STATEN ISLAND
ARTHUR KILL
NEW JERSEY
SANDY HOOK
RARITAN RIVER
NEW YORK
NEW JERSEY
N
MILES
1 0 1 2 3 4 5
CONTOUR INTERVAL .5
1.1
1.5
1.3
1.5
1.2
1.1
1.3
1.5
1.6
1.5
2.5
3.0
2.0
2.0
3.3
1.2
1.3
1.9
1.5
1.6
1.2
1.3
1.9
2.9
2.5
2.0
1.2
1.2
1.3
1.2

FIGURE 15



RARITAN BAY PROJECT

BULK DENSITY OF SEDIMENTS (KILOGRAMS/LITER)

BROOKLYN
CONEY ISLAND
NARROWS
STATEN ISLAND
SANDY HOOK
NEW JERSEY
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
1.25
> 1.25
1.25
1.00
0.75
0.50
< 0.50
> 1.00
< 0.5
0.50
0.75
1.00
MILES
1 0 1 2 3 4 5
CONTOUR INTERVAL .25 KILOGRAM SEDIMENT PER LITER

FIGURE 16

WATER CONTENT

Analyses of 28 representative samples show that sediment water content usually is either greater than 50% or less than 30% of the total weight. Intermediate values are found at only two stations. Water content values have been plotted in Figure 17. A contour has been constructed in Figure 17 for water content of 50% of total weight. Stations where water content is less than 35% are 4, 6, 7, 10, 20, 28, 45, 47, 51 and 53. Water content is greater than 50% at Stations 14, 15, 23, 24, 27, 29, 30, 54, 55, 56, 58, 60, 62 and 63. Intermediate values are found at Stations 2 and 59. The coarser sediments i.e., the sands, contain less water than the fine-grained silt sediments, as is normally the case with sedimentary rocks.

Organic Carbon Content: The organic carbon content is shown in Figure 18. In Raritan Bay sediments, the organic carbon content was between 0.1 and 6.2 percent by weight, averaging slightly less than 1%. Organic content, in general, is inversely proportioned to grain size and is relatively constant for a particular sediment body. In the Lower Bay and Keansburg sands the organic content is 0.2 and 0.4%, respectively. The percentage of organic carbon in the Sandy Hook Bay muds varied from 0.6 to 2.0%, while that of the West Raritan Bay muds, was quite high and variable, with values from 0.3 to 6.2%.

Organic Debris: The weight of organic debris in the sand size fractions is plotted in Figure 19. The organic debris in Raritan Bay was found to consist largely of amphipod tubes and wood fragments. The lowest amount of organic debris was found in the West Raritan Bay muds, which also showed the highest organic content. Hence, the organic content in the West Raritan Bay muds must be due to particles of silt-clay size.

Carbonate Content: Carbonate content of the Bay sediments, in the form of shells and shell fragments, is plotted in Figure 20. The percentage carbonate content of the sediments varies from less than 0.1% to 40.2%, and was highest at Stations 26, 44, 47, 55, 56 and 59. Shell content was generally lower in Sandy Hook Bay and in the shoals northwest of Sandy Hook. Most of the samples with high weights contained large oyster shells. Production of these shells appeared to be in the areas north of Keyport. In general the higher shell contents appear to be related to sands, while the mud areas showed the lowest production.

Carbonate in clastic sediments may originate by chemical precipitation from the overlying water or by production of animal skeletons. Since the shells in Raritan Bay show evidence of solution, a condition occurring when the water is undersaturated, there is probably little chemical precipitation. Solution of shells was evidenced by the following: (1) Articulated shells showed loss of material in certain shell layers; (2) Remains of mussel (Mytelus) shells were often found with periostracum intact but little carbonate clinging to the periostracum; and (3) Live Nassarius obsoleuts often carry shells which show material lost along the sutures. While boring organisms could account for some of these factors, no remains of such organisms were found. Since additionally no detrital carbonate derived from limestone was found, shell production must be the source of carbonates in Raritan Bay.

Mineral Content: The major light mineral constituents counted were quartz, feldspar and rock fragments. Most of the sands examined contained between 10 and 25% feldspar and rock fragments with the latter predominating. Hence, the sands can be classified as lithic sands or protoquartzites(5). Some samples contained more than 25% feldspar and rock fragments and can be called subgraywackes(5). Sediments of this sand composition, and with over 15% fine grained material were found in the western part of the Keansburg Sands. When lithified, these would develop into the rock type known as graywacke. These sands are found only in the areas where there is a transition between the sands and muds. Since lithic fragments of chemically unstable components are found in the bay sediment, the physical breakdown of source rocks must be occurring faster than chemical decomposition.

Sediment Bodies Summary: On the basis of the above studies, the sediment bodies in Raritan Bay have been divided into four groups; the Keansburg and the Lower Bay sands, and the Sandy Hook Bay and the West Raritan Bay muds.

SEDIMENT DISTRIBUTION

The origin and distribution of three types of clastic particles were evaluated to provide data on water movement. The types were the mineral muscovite, the empty shell of a small clam, and detrital coal. For each of these types, it was assumed that the grain size distribution at each source was essentially the same when multiple sources are indicated and that during distribution of sediment particles throughout the bay, the larger particles are deposited closest to the source and progressively smaller particles are deposited at progressively increasing distances from the source.

Muscovite Distribution: The colorless mica, muscovite, was selected for study because it is easily identified and is relatively light in weight and easily moved by water. Figures 21, 22 and 23 shows the distribution of muscovite retained on the #20, #40 and #100 screen respectively. The areas where the muscovite is introduced to the Bay are defined by the distribution of material retained by the #20 sieve. These areas are north and west of Sandy Hook, and near Laurence Harbor. The #40 screen size muscovite appears through much of New York Lower Bay, except in the zone south and southeast of Great Kills Harbor. In Raritan Bay, it appears in a tongue extending southwest from Great Kills Harbor and through much of the southwestern part of Raritan Bay.

Muscovite caught in the #100 screen appears through nearly all the Bay area, except for the sands north of the Keansburg area.

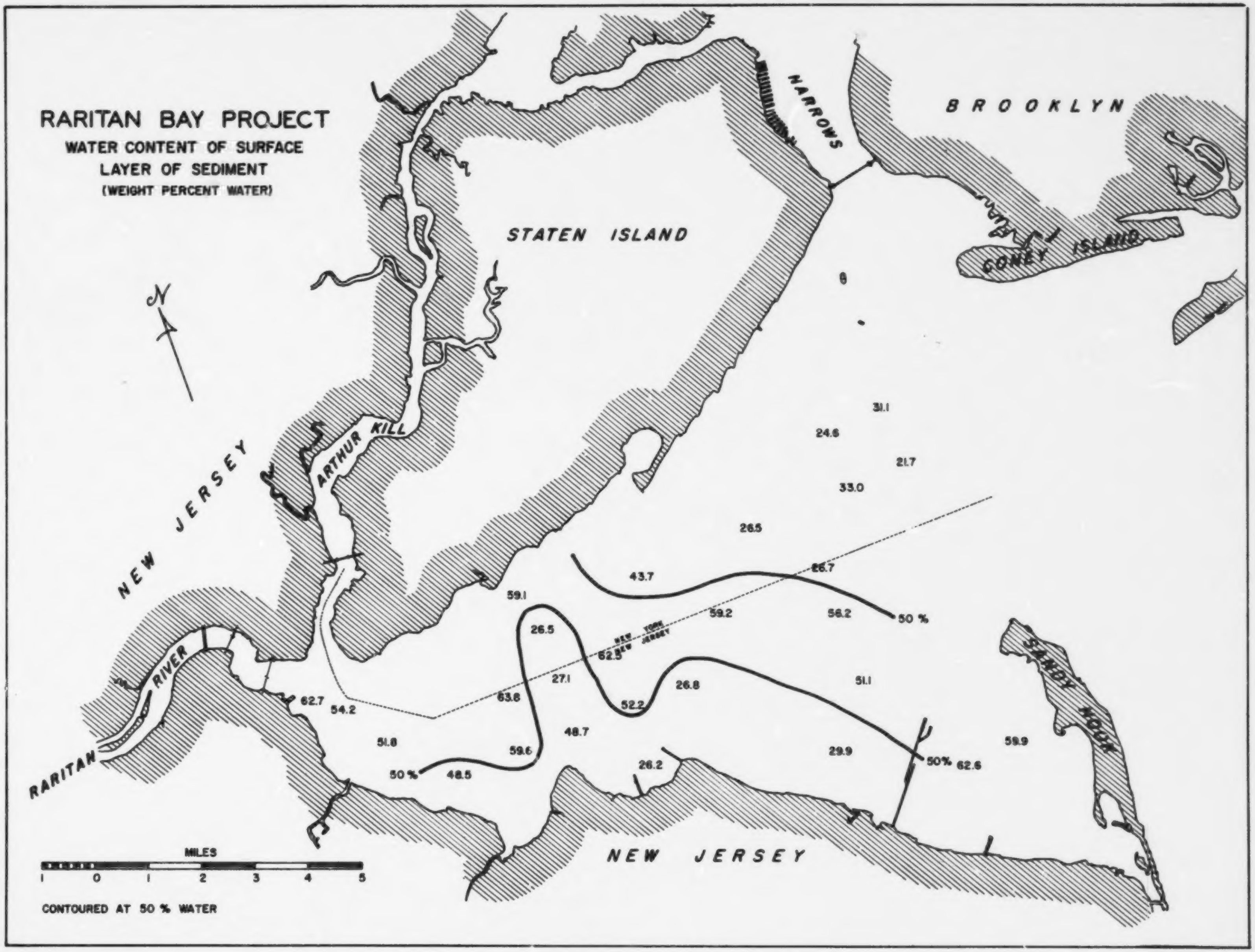
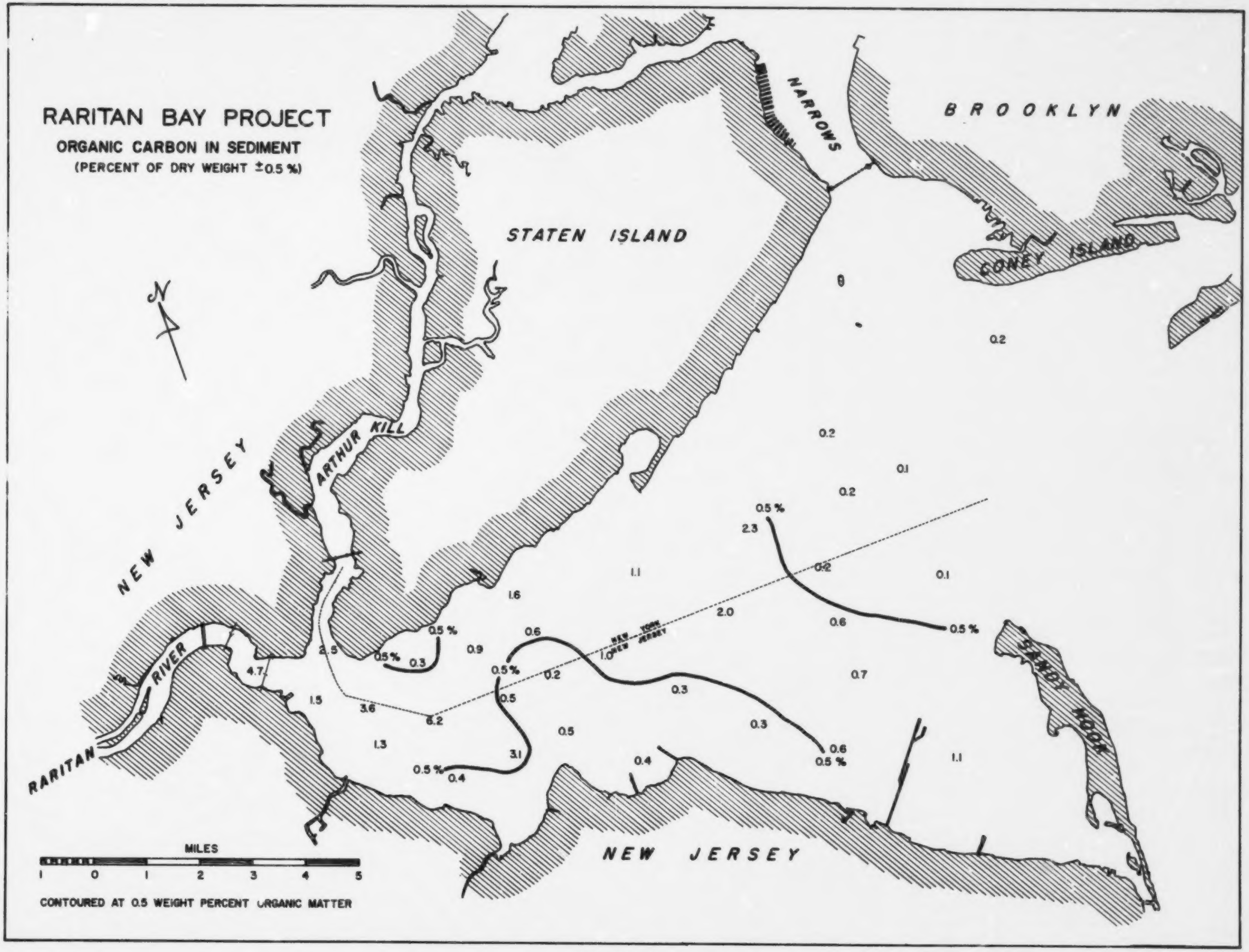

RARITAN BAY PROJECT
WATER CONTENT OF SURFACE
LAYER OF SEDIMENT
(WEIGHT PERCENT WATER)
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
SANDY HOOK
NEW YORK
NEW JERSEY
NEW JERSEY
31.1
24.6
21.7
33.0
26.5
43.7
26.7
59.1
59.2
56.2
50 %
26.5
52.5
27.1
63.8
52.2
26.8
51.1
62.7
54.2
51.8
48.7
59.6
29.9
50%
62.6
59.9
26.2
50 %
48.5
MILES
1 0 1 2 3 4 5
CONTOURED AT 50 % WATER

FIGURE 17

GPO 956-592



RARITAN BAY PROJECT
ORGANIC CARBON IN SEDIMENT
(PERCENT OF DRY WEIGHT ±0.5 %)
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
SANDY HOOK
NEW JERSEY
NEW YORK
NEW JERSEY
0.2
0.2
0.1
0.2
0.5 %
2.3
1.1
0.2
0.1
1.6
2.0
0.6
0.5 %
0.5 %
0.6
0.9
1.0
2.5
0.5 %
0.3
0.5 %
0.2
4.7
0.3
0.7
1.5
3.6
6.2
0.5
0.3
0.5
0.6
0.5 %
1.3
3.1
0.4
1.1
0.5 %
0.4
MILES
1
0
1
2
3
4
5
CONTOURED AT 0.5 WEIGHT PERCENT ORGANIC MATTER

FIGURE 18

GPO 956-592

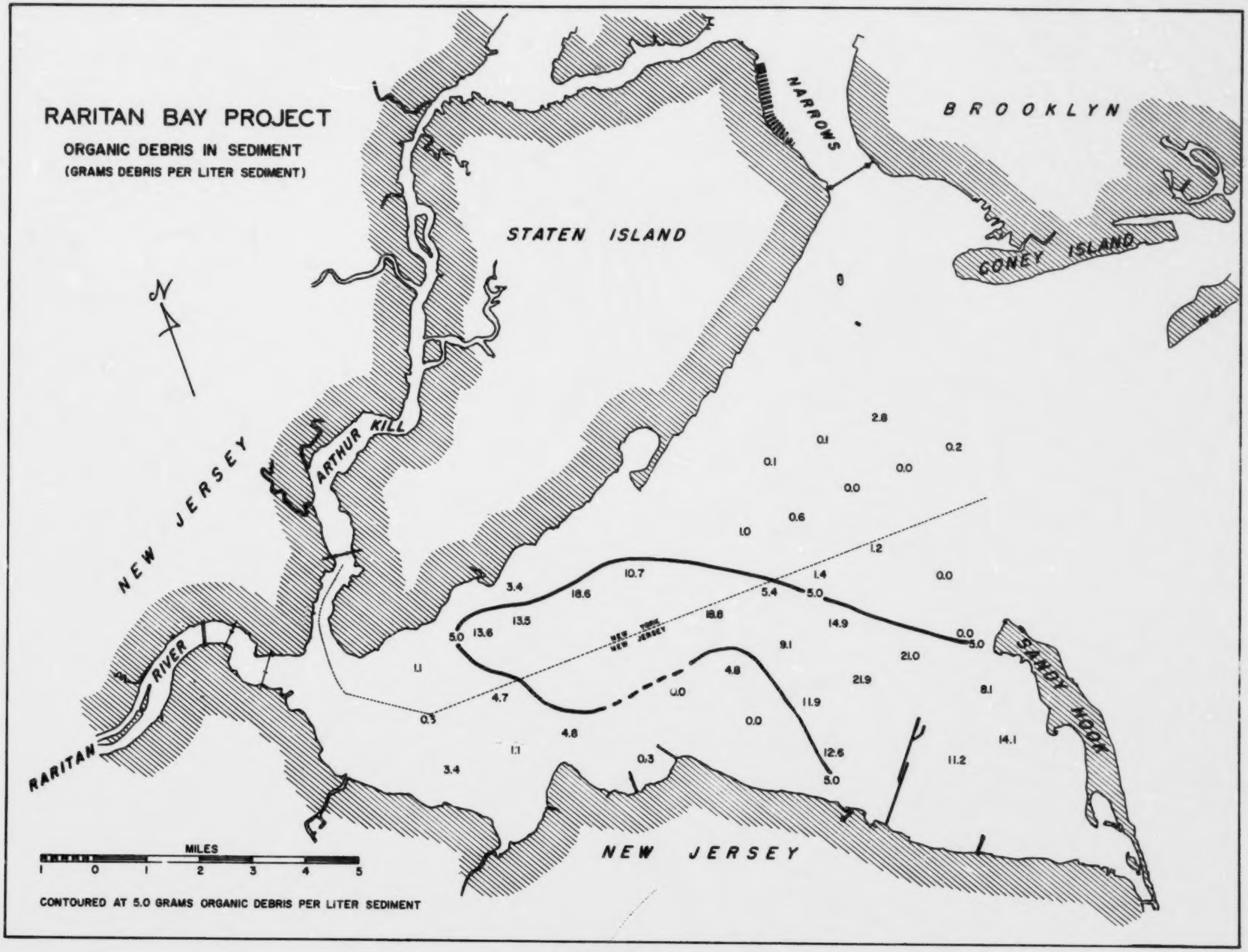

RARITAN BAY PROJECT
ORGANIC DEBRIS IN SEDIMENT
(GRAMS DEBRIS PER LITER SEDIMENT)
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
N
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
SANDY HOOK
NEW JERSEY
NEW YORK
NEW JERSEY
2.8
0.1
0.2
0.1
0.0
0.0
1.0
0.6
1.2
0.0
3.4
18.6
10.7
5.4
1.4
5.0
5.0
13.6
13.5
18.8
14.9
0.0
5.0
1.1
9.1
21.0
4.8
0.0
21.9
8.1
4.7
11.9
0.3
4.8
0.0
1.1
0.3
12.6
11.2
14.1
3.4
5.0
MILES
1 0 1 2 3 4 5
CONTOURED AT 5.0 GRAMS ORGANIC DEBRIS PER LITER SEDIMENT

FIGURE 19

GPO 956-592

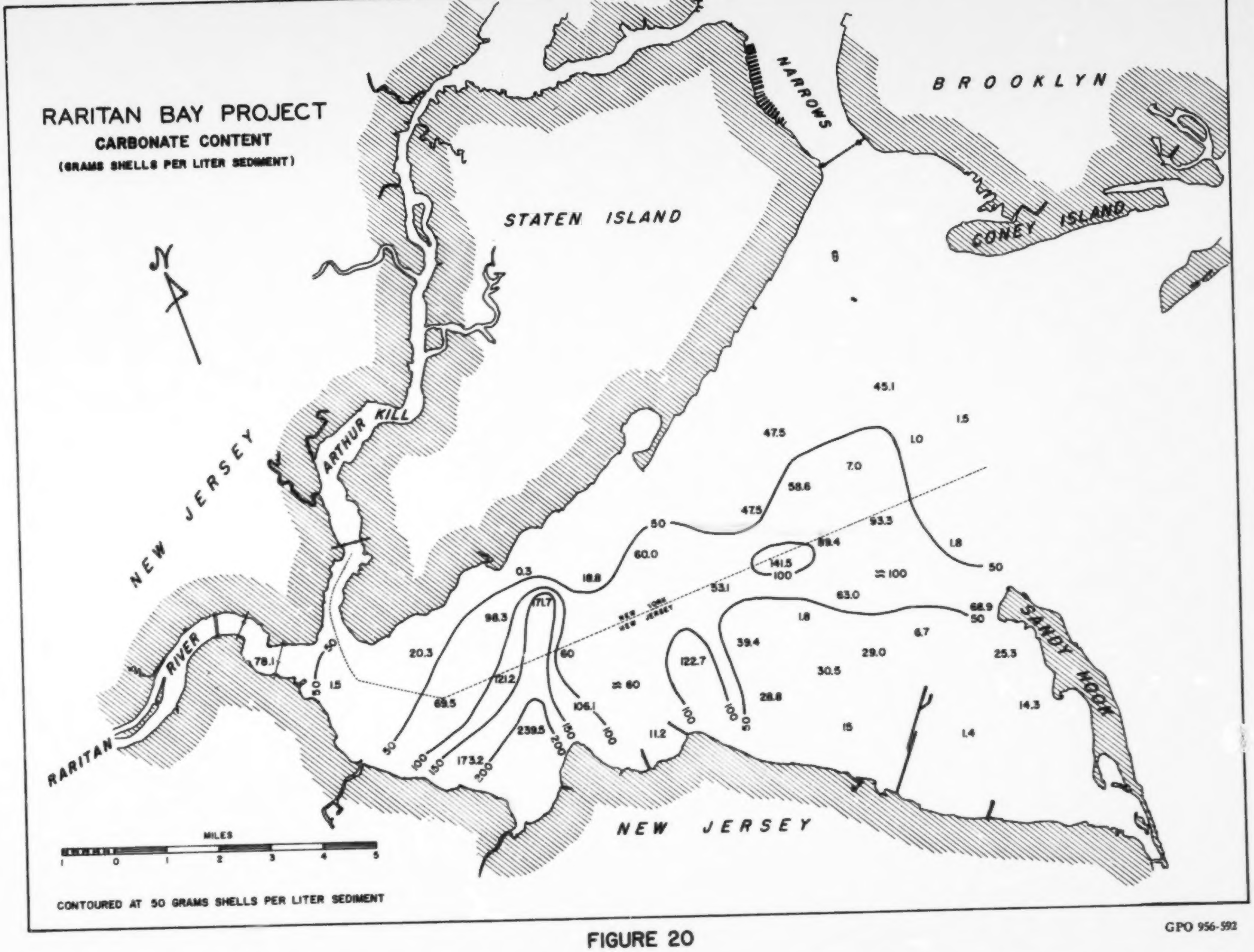

RARITAN BAY PROJECT
CARBONATE CONTENT
(GRAMS SHELLS PER LITER SEDIMENT)
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
SANDY HOOK
NEW JERSEY
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
45.1
1.5
47.5
1.0
7.0
58.6
47.5
93.3
50
89.4
1.8
141.5
100
50
60.0
0.3
18.8
53.1
≈100
63.0
68.9
50
98.3
171.7
1.8
6.7
20.3
60
39.4
29.0
25.3
78.1
122.7
30.5
50
1.5
121.2
≈60
28.8
14.3
68.5
106.1
100
100
50
15
1.4
239.5
11.2
50
100
150
173.2
200
200
150
100
MILES
1 0 1 2 3 4 5
CONTOURED AT 50 GRAMS SHELLS PER LITER SEDIMENT

FIGURE 20

GPO 956-592

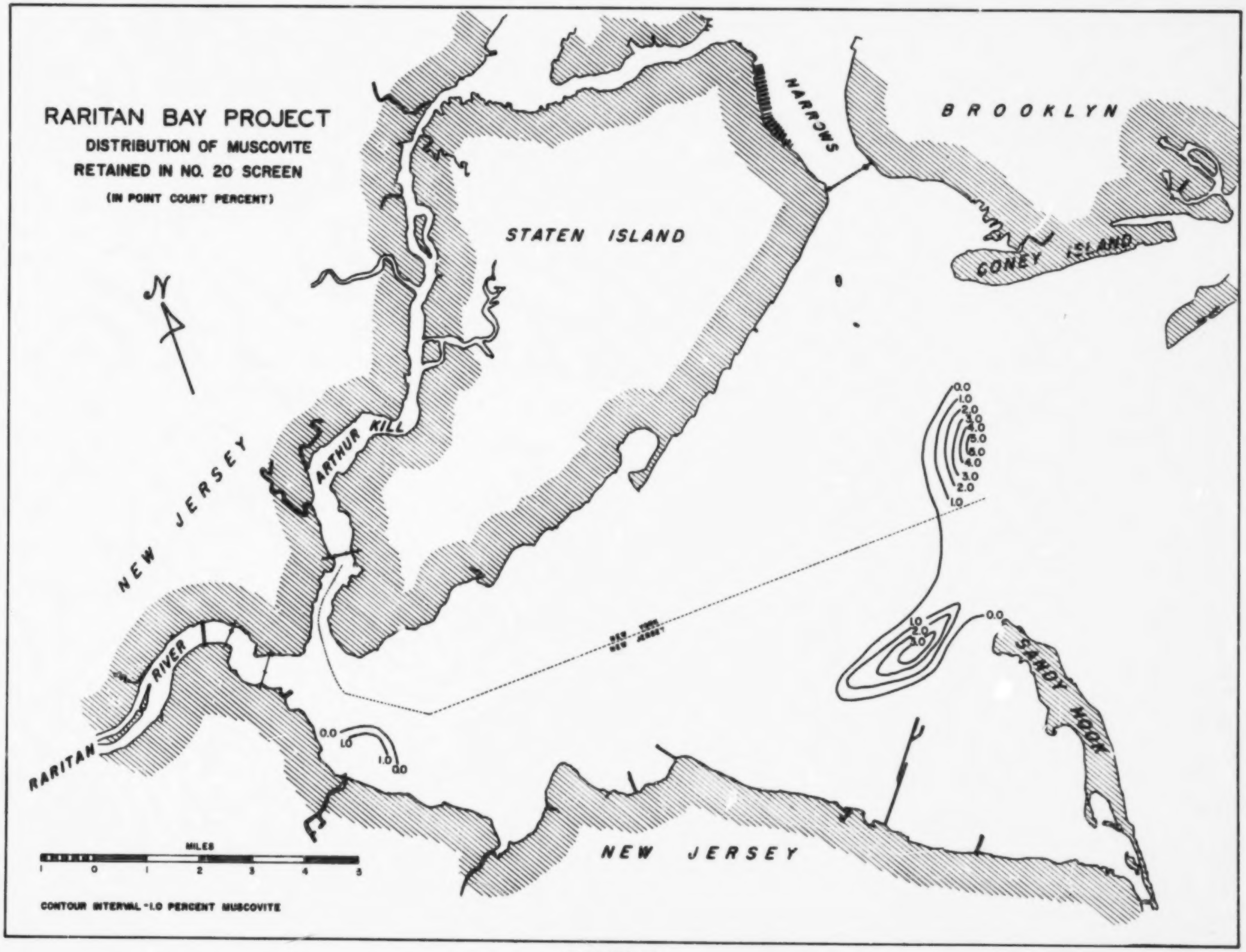

RARITAN BAY PROJECT
DISTRIBUTION OF MUSCOVITE
RETAINED IN NO. 20 SCREEN
(IN POINT COUNT PERCENT)
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
SANDY HOOK
NEW JERSEY
0.0
1.0
2.0
3.0
4.0
5.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1.0
2.0
3.0
0.0
1.0
1.0
0.0
MILES
1 0 1 2 3 4 5
CONTOUR INTERVAL - 1.0 PERCENT MUSCOVITE

FIGURE 21

GPO 956-592

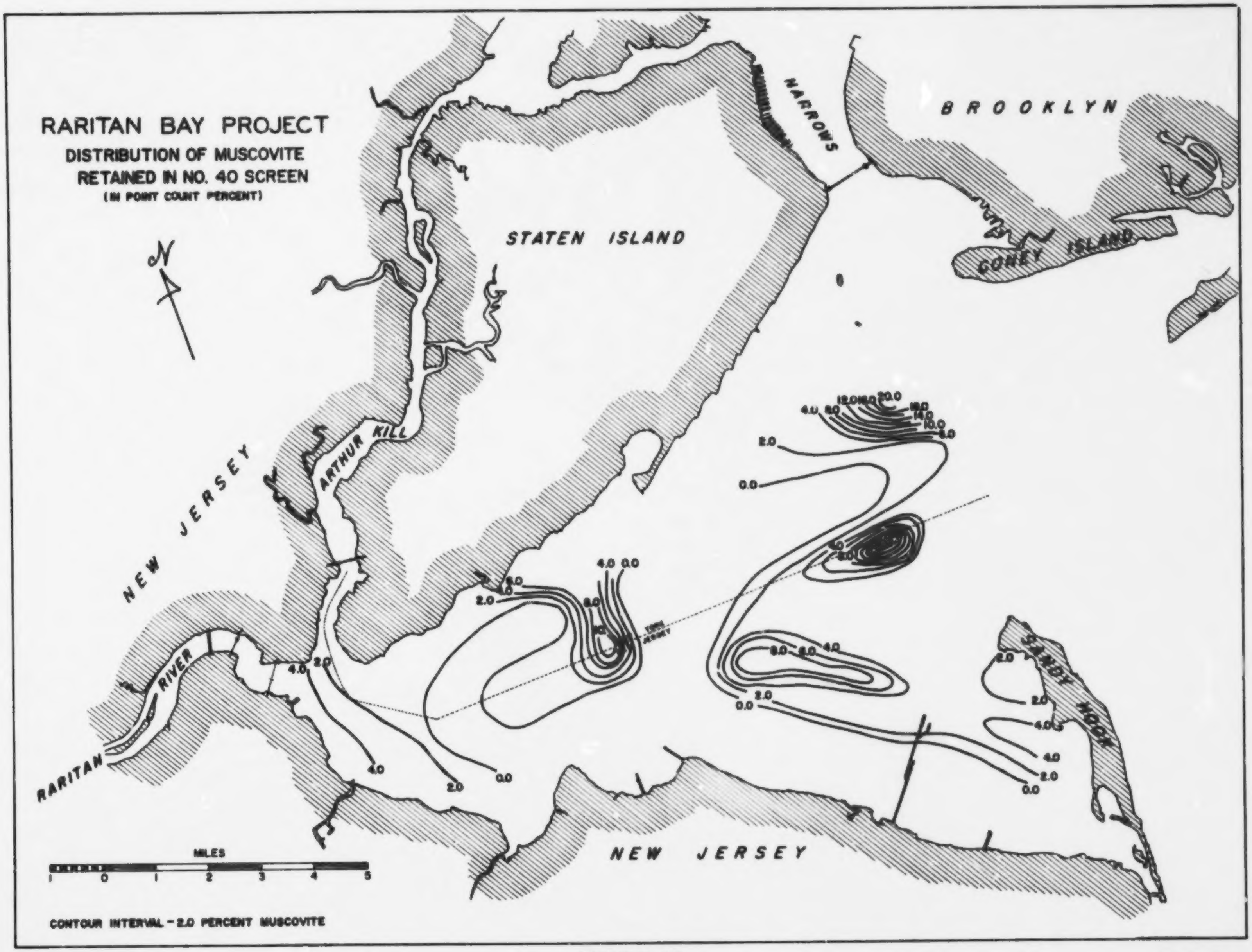
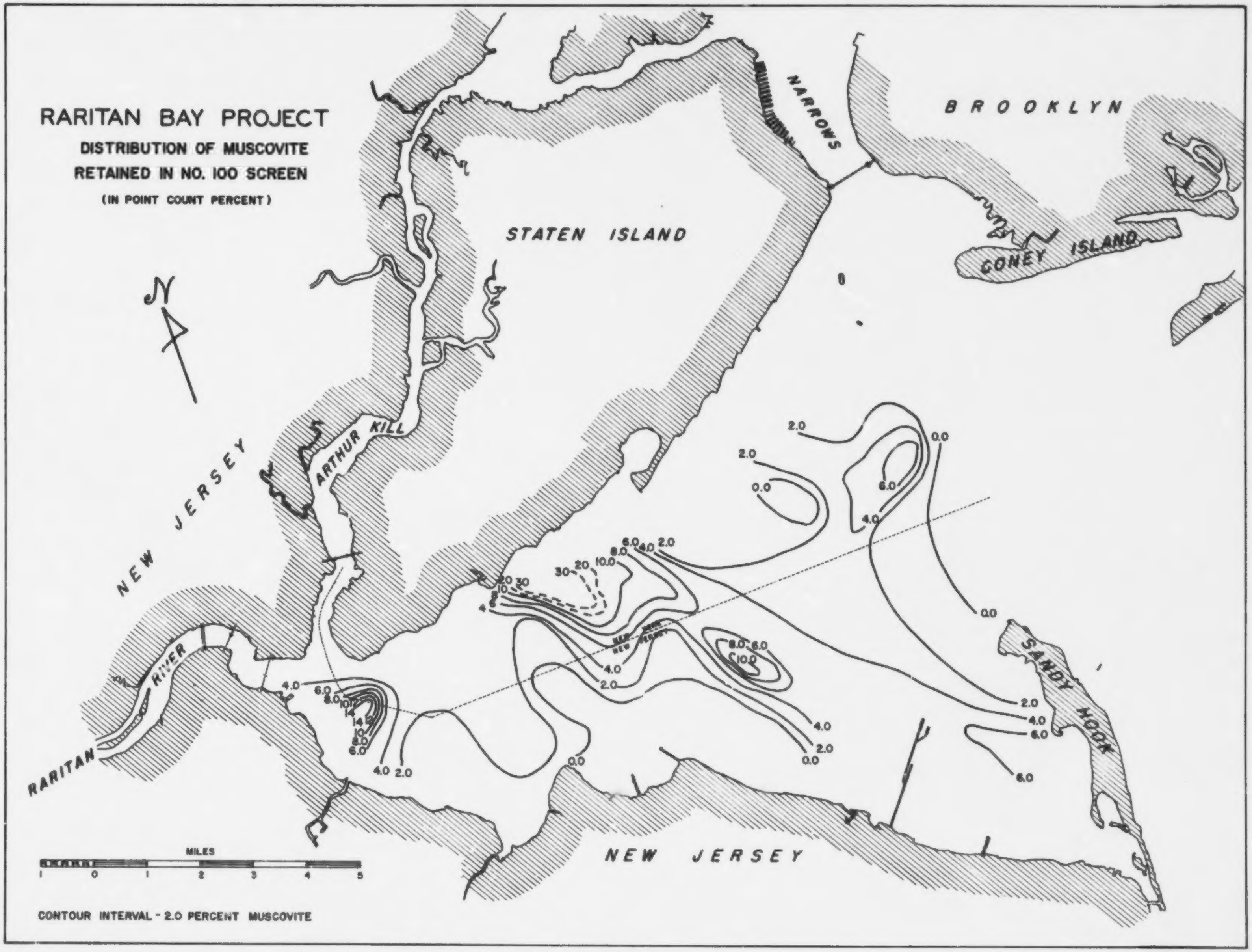

RARITAN BAY PROJECT
DISTRIBUTION OF MUSCOVITE
RETAINED IN NO. 40 SCREEN
(IN POINT COUNT PERCENT)
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
SANDY HOOK
NEW JERSEY
ARTHUR KILL
RARITAN
RIVER
NEW JERSEY
MILES
1
0
1
2
3
4
5
CONTOUR INTERVAL - 2.0 PERCENT MUSCOVITE
0.0
2.0
4.0
8.0
12.0
16.0
20.0
18.0
14.0
10.0
6.0

FIGURE 22

GPO 956-392



RARITAN BAY PROJECT
DISTRIBUTION OF MUSCOVITE
RETAINED IN NO. 100 SCREEN
(IN POINT COUNT PERCENT)

BROOKLYN
CONEY ISLAND
NARROWS
STATEN ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
SANDY HOOK
NEW JERSEY
N
MILES
1 0 1 2 3 4 5
0.0
2.0
4.0
6.0
8.0
10.0
14
20
30

CONTOUR INTERVAL - 2.0 PERCENT MUSCOVITE

FIGURE 23

GPO 956-592

While muscovite can form in the marine environment, particles so formed rarely show signs of abrasion. The particles found in Raritan Bay showed signs of abrasion, so probably were transported into the bay. The muscovite appears to be introduced from the ocean east of the bay, and from an area where a suitable rock, the Raritan Formation, crops out. It is spread progressively through much of the bay, with net movement toward the area southeast of Seguine Point.

Mollusk Shell Distribution: Final transport and distribution of authigenic sediment particles (particles produced within the area of sedimentation) was determined by studying the distribution of shells of a particular mollusk. These shells can be considered as authigenic particles if it can be shown that the shells are largely produced within the confines of the bay. The small estuarine clam Mulinia lateralis was chosen because it is relatively common and its shells are sufficiently small to be moved about by forces of sediment distribution.

As shown by the distribution of the live clam in Figure 24, these shells are largely produced in three areas, north of Port Monmouth, N.J., north of Keyport, and southwest of Seguine Point. Figure 25 shows that the shells are deposited (1) near the production areas; (2) in the fine grained sediments north of the Port Monmouth - Keansburg area; and (3) in a tongue extending north of Keyport. The shells appear to have been transported north from the Keyport area, and west from the Port Monmouth area.

Detrital Coal Distribution: Detrital coal, including cinders, is a clastic element exclusively introduced by man in the Raritan Bay area, since there are no outcrops of coal in the bay or on tributary streams. Coal can be introduced into the bay from coal-using industries along the bay and its tributaries, and from ships bringing coal to these industries.

Figures 26, 27, 28 and 29 show the distribution of coal retained on #5, #20, #40 and #100 screens respectively. These figures show that coal is introduced into Raritan Bay from four areas, around Perth Amboy, above Keyport, near Port Monmouth, and east of Old Orchard Shoal lighthouse. Ultimate movement is toward the area northwest of Keyport, southwest of Great Kills and the Old Orchard Shoal lighthouse. As previously noted, this assumes that grain size distributions for the different sources are essentially identical.

Sediment Movement and Distribution: The results of the above studies of sediment distribution indicate permanent effects of water movement within the Raritan Bay system. Based upon the patterns of muscovite, clam shells and detrital coal distributions, it would appear that sediments, although introduced into the bay at various places, are all moved toward the roughly quadrilateral area between Seguine Point, Great Kills, Keyport and Keansburg. While river water moves through the entire estuary, its transport influence is felt primarily in the western portion of the bay, while the influence of the ocean predominates in the eastern portion. The net effective movement from these two forces is thus toward the area described above.

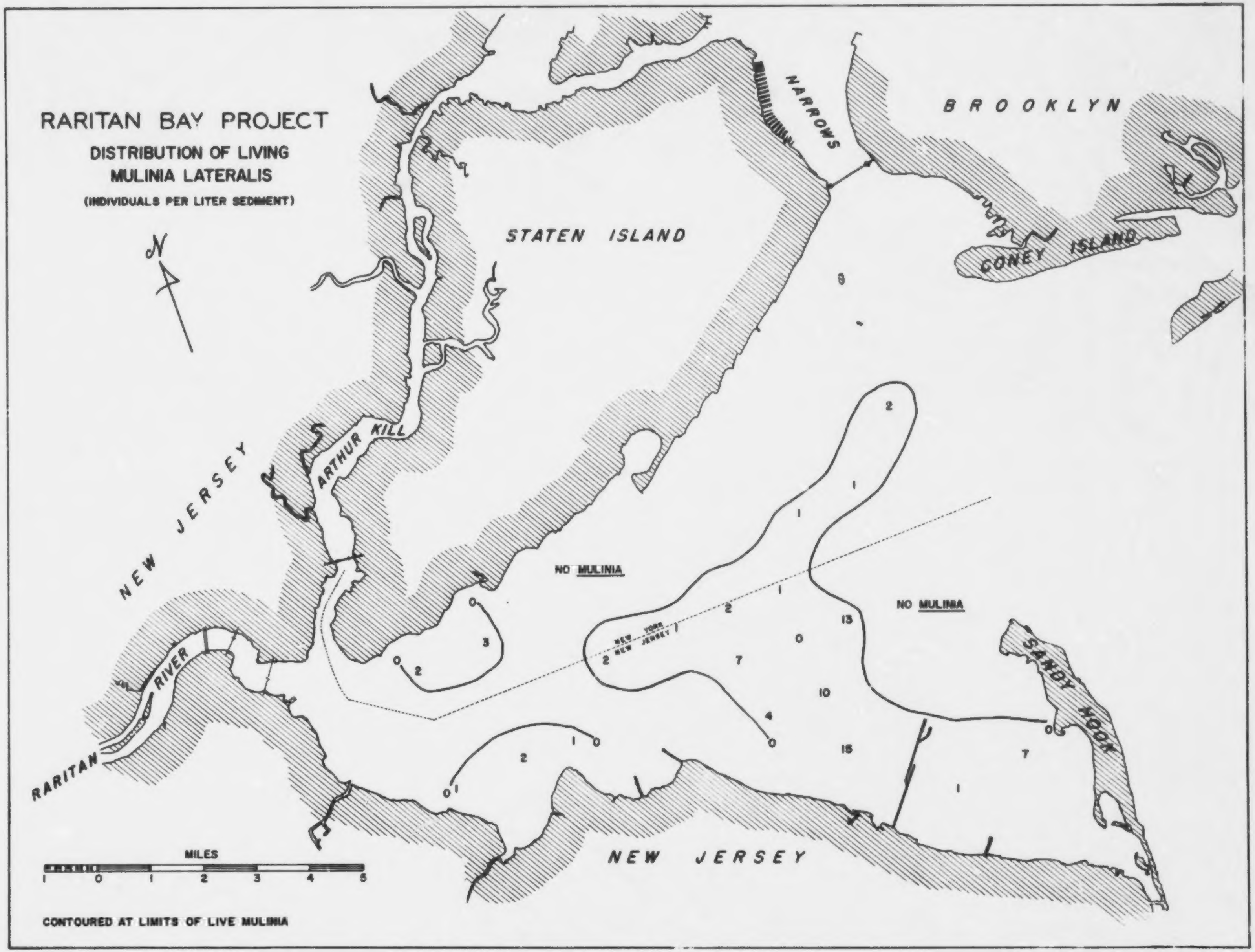
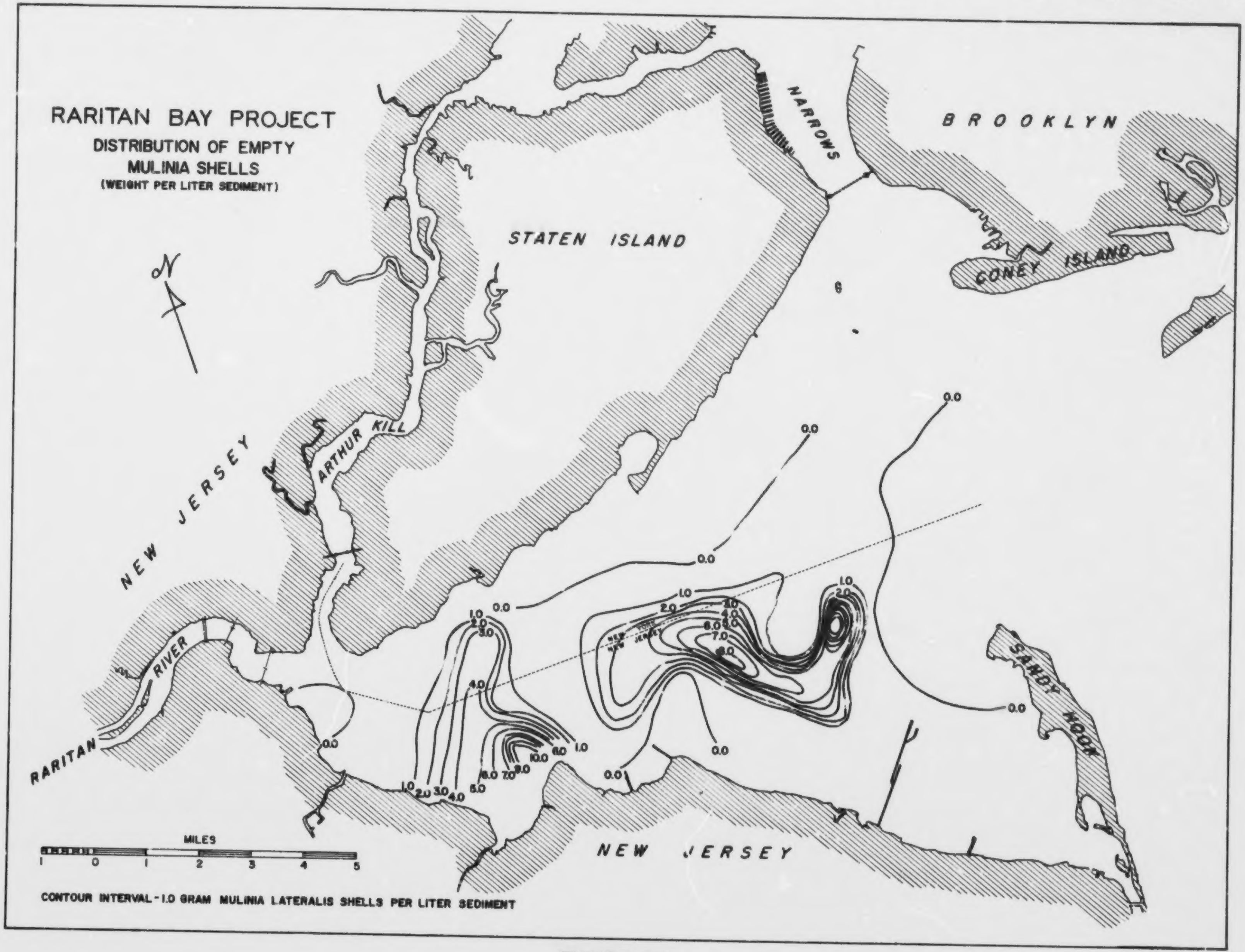

RARITAN BAY PROJECT
DISTRIBUTION OF LIVING
MULINIA LATERALIS
(INDIVIDUALS PER LITER SEDIMENT)
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NO MULINIA
NEW YORK
NEW JERSEY
SANDY HOOK
NEW JERSEY
MILES
1 0 1 2 3 4 5
CONTOURED AT LIMITS OF LIVE MULINIA
0 2 3 0 2 1 0 01 2 1 1 2 1 13 0 7 10 4 0 15 7 1 0 8

FIGURE 24

GPO 956-592



RARITAN BAY PROJECT
DISTRIBUTION OF EMPTY
MULINIA SHELLS
(WEIGHT PER LITER SEDIMENT)

STATEN ISLAND
BROOKLYN
NARROWS
CONEY ISLAND
SANDY HOOK
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW JERSEY
N
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
10.0
MILES
1 0 1 2 3 4 5

CONTOUR INTERVAL - 1.0 GRAM MULINIA LATERALIS SHELLS PER LITER SEDIMENT

FIGURE 25

GPO 956-592

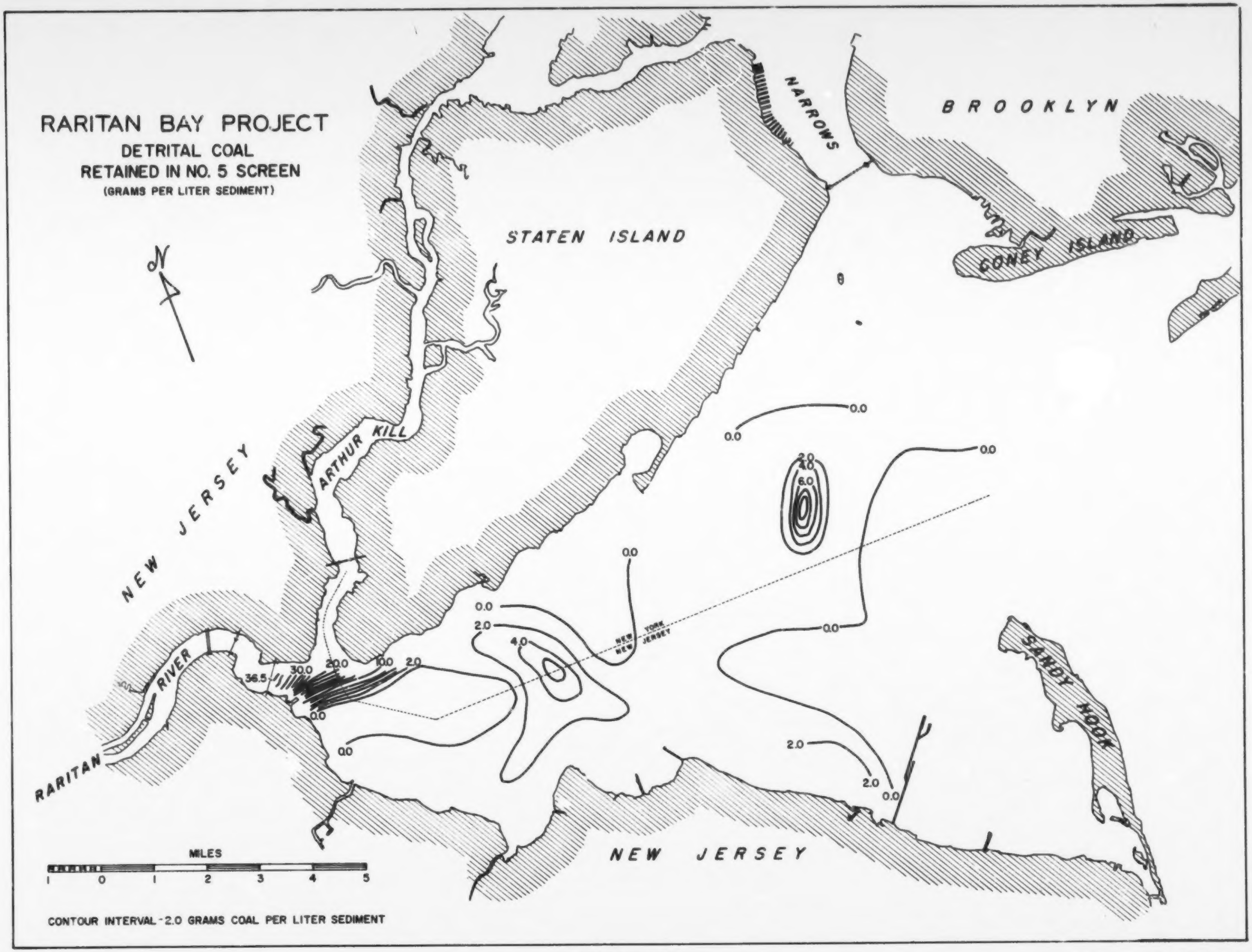

RARITAN BAY PROJECT
DETRITAL COAL
RETAINED IN NO. 5 SCREEN
(GRAMS PER LITER SEDIMENT)
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
SANDY HOOK
NEW JERSEY
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW YORK
NEW JERSEY
N
0.0
2.0
4.0
6.0
10.0
20.0
30.0
36.5
MILES
1 0 1 2 3 4 5
CONTOUR INTERVAL - 2.0 GRAMS COAL PER LITER SEDIMENT

FIGURE 26

GPO 956-592

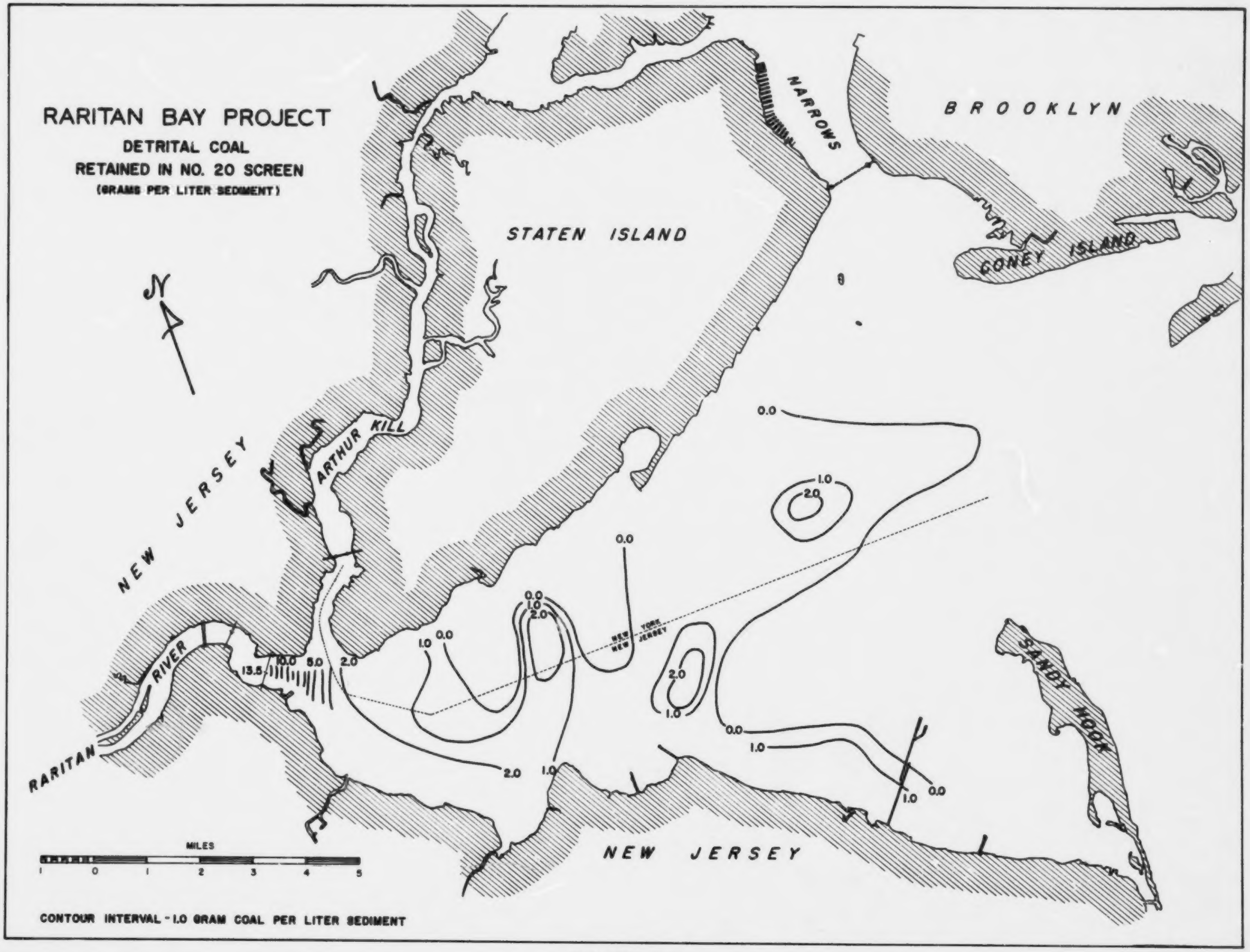

RARITAN BAY PROJECT
DETRITAL COAL
RETAINED IN NO. 20 SCREEN
(GRAMS PER LITER SEDIMENT)
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
SANDY HOOK
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW JERSEY
N
NEW YORK
NEW JERSEY
0.0
1.0
2.0
5.0
10.0
13.5
MILES
1 0 1 2 3 4 5
CONTOUR INTERVAL - 1.0 GRAM COAL PER LITER SEDIMENT

FIGURE 27

GPO 956-592

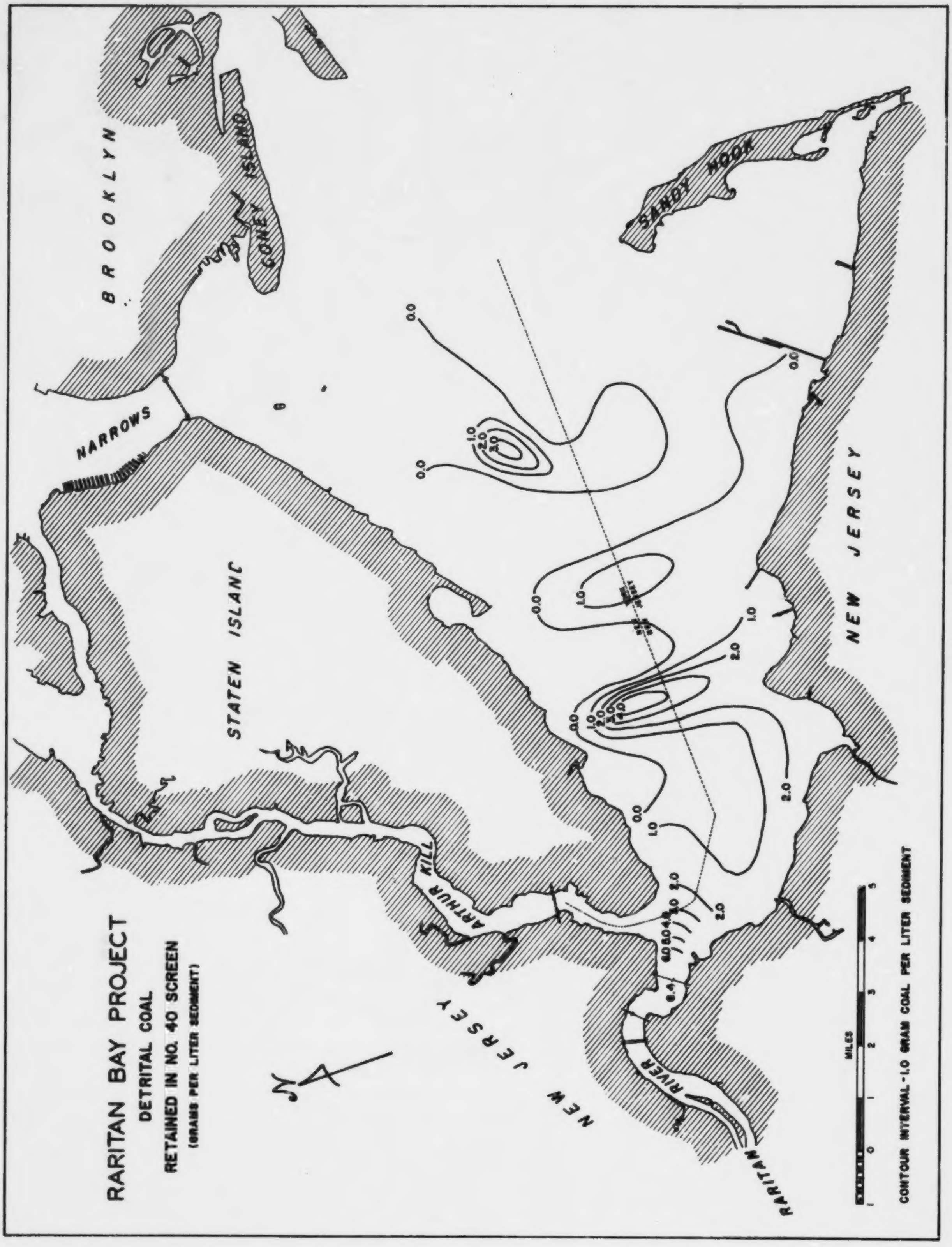
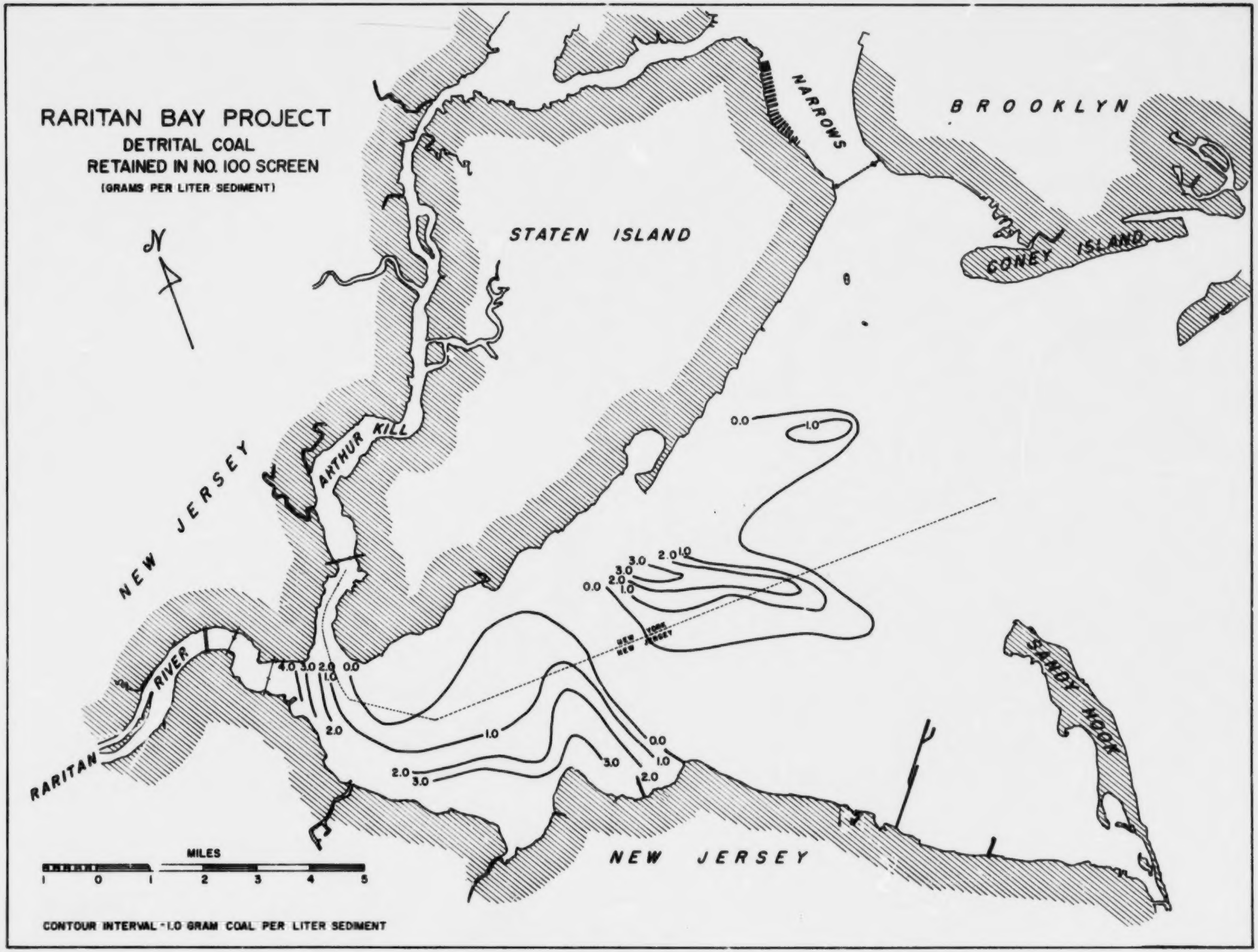

RARITAN BAY PROJECT
DETRITAL COAL
RETAINED IN NO. 40 SCREEN
(GRAMS PER LITER SEDIMENT)
BROOKLYN
CONEY ISLAND
NARROWS
STATEN ISLAND
SANDY HOOK
NEW JERSEY
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
0.0
1.0
2.0
3.0
4.0
6.4
MILES
0
1
2
3
4
5
CONTOUR INTERVAL-1.0 GRAM COAL PER LITER SEDIMENT

FIGURE 28



RARITAN BAY PROJECT
DETRITAL COAL
RETAINED IN NO. 100 SCREEN
(GRAMS PER LITER SEDIMENT)

N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
SANDY HOOK
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW JERSEY
NEW YORK
NEW JERSEY
0.0
1.0
2.0
3.0
4.0
MILES
1 0 1 2 3 4 5

CONTOUR INTERVAL - 1.0 GRAM COAL PER LITER SEDIMENT

FIGURE 29

GPO 956-592

FINDINGS AND CONCLUSIONS

FINDINGS

Major findings of the study of Raritan Bay geology are as follows:

1. The shorelines of the Raritan estuary are relatively straight, with linear continuity between sea cliffs and wide sandy beaches. The bay shoreline also contains some tidal marshes on the New Jersey Coast.
2. High chlorinity water occupies the northern portion of the estuary; lower chlorinity water is found in the southern portion. The main water masses show much interfingering with one another.
3. Wind appears to affect the position of the water masses. With a west wind the main tongue of high chlorinity water moves close to the Staten Island shore, while an east wind moves the main tongue of high chlorinity water toward the central position of the bay.
4. The floor of the estuary is made up of four major sediment bodies. Sands with an average size of 300 to 400 microns are found north of the New Jersey shore and in Lower New York Bay. The sands are well sorted and have low organic and water content. Silts, or muds, with median diameters of 20 to 80 microns are found in the western part of Raritan Bay and in Sandy Hook Bay. The silts are poorly sorted and have high organic and water content.
5. Most of the sands can be classified as lithic or subgreywackes.
6. The sands generally are denser than the muds. Bulk densities of the sands are usually over 1.0 kg/l, compared to general values of less than 0.5 kg/l for the muds.
7. Carbonate content ranges from 0.1% to 42% of total sediment by weight. The highest quantities of carbonate per unit volume of sediment are found in a narrow zone parallel to the long axis of the estuary. Carbonate is produced by shell bearing organisms rather than by chemical composition.
8. Organic content ranges from 0.1% to 6% by weight. All value greater than 2.0% occur in the West Raritan Bay muds.
9. Organic debris, consisting generally of amphipod tubes and wood fragments, varies in the estuary, but is generally highest in Sandy Hook Bay.
10. A study of the disposal of muscovite particles, shells of a small clam, and detrital coal showed that while these materials were introduced into the estuary at varying locations, increasingly smaller particles were found progressively closer to the area bounded by Seguine Point, Great Kills, Keansburg and Keyport.
11. Detrital coal found in the bay sediment is concentrated near industrial sources, particularly the Perth Amboy area.

CONCLUSIONS

Major conclusions drawn from this study are as follows:

1. The shoreline of the Raritan estuary has reached early maturity in the geomorphic cycle of shoreline development.
2. Movement of high chlorinity water is centered in the northerly portion of the bay while fresher water moves through the southern portion.
3. The bay floor is made up of four major sediment bodies, referred to as the Lower Bay and Keansburg sands, and the Sandy Hook Bay and West Raritan Bay muds.
4. The high organic carbon content found in West Raritan Bay is due to small particles of organic matter, probably the result of an excess of organic matter introduced through pollution.
5. Sediment particles originating at various locations in the bay are moved progressively toward the area bounded by Seguine Point, Great Kills, Keyport and Keansburg.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
BUREAU OF DISEASE PREVENTION AND ENVIRONMENTAL CONTROL
National Center for Urban and Industrial Health

Water Supply and Sea Resources Program
NORTHEAST RESEARCH CENTER
Narragansett, Rhode Island 02882

A Report on the

Analytical Chemical Data on Shellfish from Raritan Bay

From the Chemistry Section, NERC

July 1965

Introduction

The cooperative role of the Northeast Research Center in the Raritan Bay Project has been based upon a two-fold interest in the quality of the environmental water as related to biological and chemical contaminants, and the distribution of the shellfish resource. Of special interest has been the effect of these contaminants on shellfish including reclamation of this food source.

This study has consisted of two phases. Phase I was a resource study concerned with shellfish density (1) while Phase II has involved the investigation of quality characteristics of the overlying water, silt, and clam meats.

The chemical data described herein represents a contribution to the quality study of the Raritan Bay Project (2, 3, 4). More specifically, Raritan Bay shellfish have been analyzed at NERC for selected trace metals, pesticides, as well as certain other pertinent organic materials.

A description of our methods and procedures, including a discussion of the data obtained, follows.

Materials and Methods

Approximately seventy samples were selected from some four hundred collected during 1963 and 1964 from five areas within the Raritan Bay. These samples, representing twenty stations within these areas, were chosen on the basis of shellfish concentrations and the prevailing currents, as being most indicative of the quality information that we are seeking. The areas and stations along with the shellfish densities and currents are illustrated in the map of Raritan Bay shown in Figure I. Figure II summarizes the total wet weight of the whole-sample homogenate according to area, station, and date of collection.

The shucked and frozen samples, as received from the Raritan Bay Project, were thawed and drained via standard NERC procedures in an open Buchner funnel. The samples were weighed and homogenized in a Waring blendor and portions of the material were removed for analysis. The remainder was placed in plastic bags inside of pint containers and refrozen for additional sampling if necessary. Portions of the material removed were lyophilized for phenols and mineral oil determinations. The rest of the homogenate removed was used in the wet state for both metals and pesticide analysis.

Analysis of Mineral Oils

NERC modifications of the chromotographic method of H.D. Silverberg (5) was used for the determination of mineral oils.

I. Preparation:

A. Reagents

1) Chromatographic column: - 3x30 CM with stopcock at the constricted end.

2) Alumina (absorbent): - 80-200 mesh Fisher No. A. 540.
3) Petroleum Ether: ACS Grade.
4) Carbon Tetrachloride.

B. Sample Preparation

Lyophilize or oven-dry sample on a non-absorbent surface until crisp and brittle. Grind and mix well, store in air-tight container. Record the dry weight.

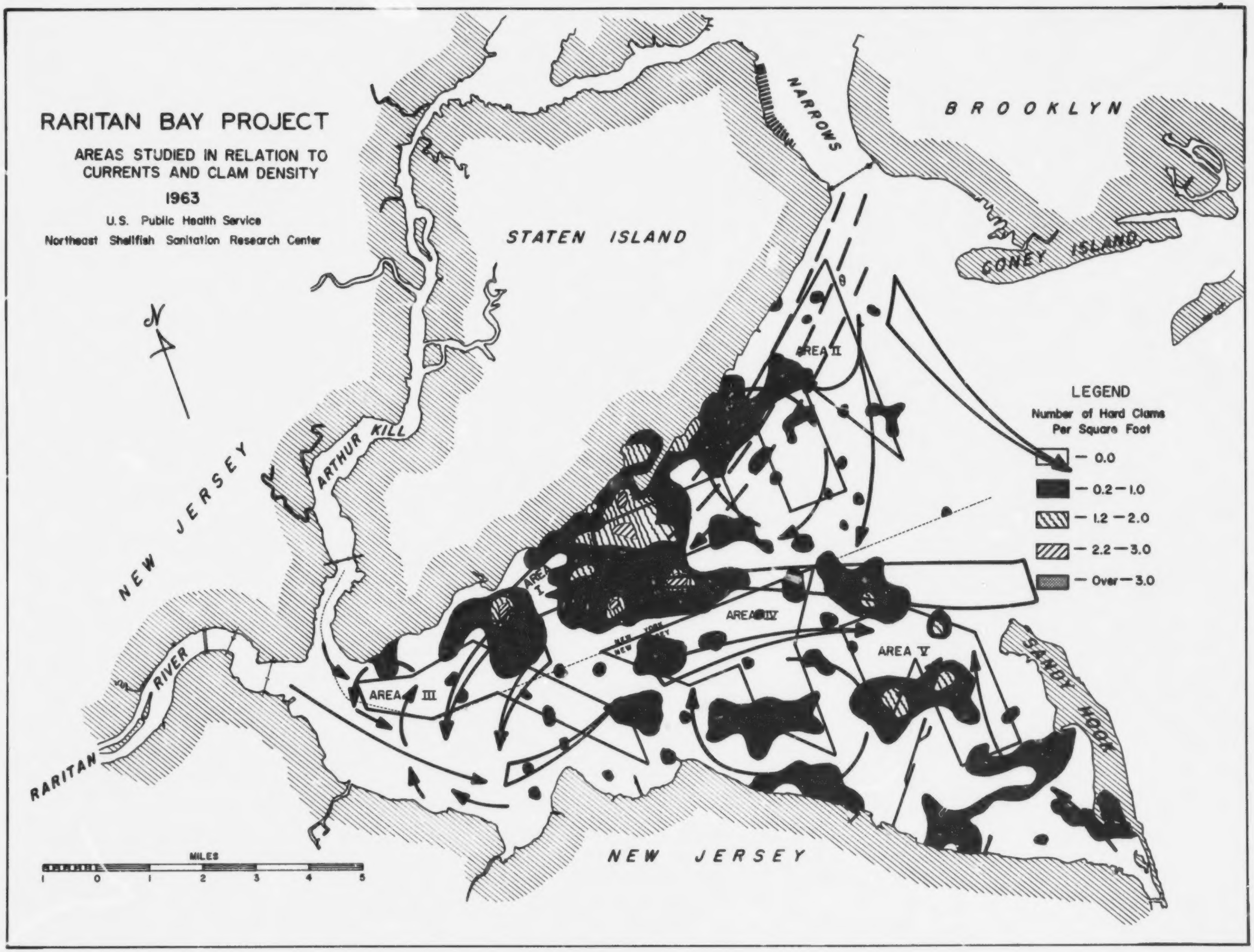

RARITAN BAY PROJECT
AREAS STUDIED IN RELATION TO CURRENTS AND CLAM DENSITY
1963
U.S. Public Health Service
Northeast Shellfish Sanitation Research Center
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
AREA I
AREA II
AREA III
AREA IV
AREA V
NEW YORK
NEW JERSEY
SANDY HOOK
LEGEND
Number of Hard Clams Per Square Foot
— 0.0
— 0.2 — 1.0
— 1.2 — 2.0
— 2.2 — 3.0
— Over — 3.0
MILES
1
0
1
2
3
4
5

FIGURE I

GPO 956-592

FIGURE II

Summary of Samples by Area and Station

Area #	Station #	Date	Total Wet Weight of Homogenized Sample in Grams
I	1	8/7/63	125
	1	11/5/63	476
	1	11/10/63	444
	1	12/10/63	389
	1	1/27/64	406
	1	3/24/64	427
	1	5/25/64	390
	2	8/12/63	800
	2	11/5/63	494
	2	11/19/63	456
	2	12/10/63	432
	2	1/27/64	392
	2	3/24/64	405
	2	5/25/64	414
	3	8/21/63	459
	3	8/21/63	442
	3	11/5/63	478
	3	11/19/63	490
	3	12/11/63	421
	3	1/27/64	390
	3	3/24/64	405
	3	5/25/64	307
I	4	8/12/63	404
	4	11/5/63	499
	4	11/19/63	483
	4	1/20/64	426
	4	3/16/64	449
	4	3/31/64	471
	30	8/7/63	349
	30	11/6/63	418
	30	11/19/63	408
	30	12/10/63	499
	30	2/6/64	406
	30	3/30/64	153
	30	5/26/64	221
	31	8/7/63	375
	31	11/6/63	415
	31	11/19/63	468
	31	12/10/63	447
	31	3/30/64	389
	31	5/25/64	326
	41	8/21/63	462
	41	8/21/63	496

FIGURE II (Cont'd.)

Summary of Samples by Area and Station

Area #	Station #	Date	Total Wet Weight of Homogenized Sample in Grams
I	41	11/5/63	492
	41	11/19/63	397
	41	12/11/63	420
	41	1/20/64	408
	41	3/16/64	437
	41	3/31/64	237
	42	8/19/63	594
	42	11/5/63	460
	42	11/19/63	441
	42	12/11/63	425
	42	1/27/64	376
	42	3/24/64	423
	43	8/7/63	165
	43	11/5/63	505
	43	11/19/63	434
	43	12/10/63	384
	43	1/17/64	431
	43	3/24/64	409
	43	5/25/64	402
	44	10/7/63	203
	44	11/6/63	416
	44	11/19/63	432
	44	12/10/63	391
	44	2/5/64	416
	44	3/30/64	414
	44	5/25/64	406

Area #	Station #	Date	Total Wet Weight of Homogenized Sample in Grams
II	5	8/26/63	155
	5	8/28/63	362
	5	11/5/63	483
	5	11/12/63	497
	5	12/2/63	274
	5	12/9/63	386
	5	1/20/64	404
	5	3/16/64	223
	5	3/31/64	411
	5	5/26/64	193
	6	11/4/63	470
	6	11/12/63	423
	6	12/2/63	413
	6	1/20/64	399
	6	3/23/64	463
	6	5/26/64	231
	7	8/28/63	480
	7	11/4/63	512
	7	11/12/63	465
	7	12/2/63	383
	7	1/20/64	374
	7	3/23/64	365
	7	5/26/64	301
	10	11/4/63	486
	10	11/12/63	465
	10	12/2/63	383

FIGURE II (Cont'd.)

Summary of Samples by Area and Station

Area #	Station #	Date	Total Wet Weight of Homogenized Sample in Grams
II	10	5/26/64	301
	20	10/21/63	541
	20	11/4/63	501
	20	11/12/63	473
	20	12/2/63	104
	20	1/20/64	392
	20	3/23/64	410
	20	5/26/64	418
	21	8/12/63	415
	21	8/21/63	478
	21	11/5/63	378
	21	11/12/63	510
	21	12/2/63	384
	21	1/20/64	430
	21	3/24/64	416
	36	8/28/63	605
	36	11/4/63	506
	36	11/12/63	467
	36	12/2/63	443
	36	1/20/63	423
	36	3/31/63	407
	36	5/26/63	369
	37	11/4/63	470
	37	11/12/63	478

Area #	Station #	Date	Total Wet Weight of Homogenized Sample in Grams
II	37	12/2/63	389
	37	3/16/64	323
	37	3/31/64	413
	37	5/26/64	416
	39	8/28/63	498
	39	11/4/63	477
	39	11/12/63	444
	39	12/2/63	427
	39	1/20/64	385
	39	3/16/64	431
	39	3/31/64	392
	40	11/5/63	391
	40	11/12/63	478
	40	12/2/63	438
	40	1/20/64	395
III	32	8/7/63	250
	32	11/6/63	481
	32	11/20/63	453
	32	12/4/63	360
	33	11/20/63	373
	33	12/6/63	347
	33	12/11/63	424
	33	2/6/64	406

FIGURE II (Cont'd.)

Summary of Samples by Area and Station

Area #	Station #	Date	Total Wet Weight of Homogenized Sample in Grams
III	33	3/30/64	304
	33	5/25/64	289
	45	8/7/63	253
	45	11/20/63	412
	45	11/30/63	481
	45	12/9/63	447
	45	3/30/64	229
	46	8/7/63	170
	46	10/31/63	418
	46	11/20/63	436
	46	12/9/63	439
	46	1/27/64	396
	46	6/2/64	401
	53	8/28/63	71
	53	10/31/63	449
	53	11/20/63	492
	53	2/5/64	443
	53	3/30/64	401
	53	6/2/64	351
	54	10/29/63	457
	54	11/20/63	414
	54	12/9/63	434
	54	2/5/64	403

Area #	Station #	Date	Total Wet Weight of Homogenized Sample in Grams
III	54	3/30/64	418
	54	6/2/64	377
	56	8/7/63	285
	56	10/31/63	467
	56	11/20/63	412
	56	12/9/63	368
	56	2/6/64	399
	56	3/30/64	335
	57	8/7/63	204
	57	11/6/63	356
	57	11/9/63	413
	57	11/13/63	419
	57	11/20/63	417
	57	2/6/64	369
	57	3/30/64	368
	57	5/25/64	305
	58	10/31/63	147
	58	11/20/63	377
	58	12/9/63	374
	58	2/6/64	424
	58	3/30/64	196
	61	11/6/63	421
	61	11/20/63	412
	61	12/9/63	396
	61	2/6/64	421
	61	3/30/64	281
	61	5/25/64	171

FIGURE II (Cont'd.)

Summary of Samples by Area and Station

Area #	Station #	Date	Total Wet Weight of Homogenized Sample in Grams
IV	22	8/21/63	426
	22	8/21/63	494
	22	10/28/63	504
	22	11/18/63	458
	22	12/4/63	434
	22	1/20/64	390
	22	3/16/64	382
	22	6/1/64	187
	22	6/2/64	402
	25	10/28/63	474
	25	11/18/63	453
	25	12/4/63	424
	25	12/11/63	452
	25	6/1/64	320
	26	8/19/63	132
	26	10/28/63	489
	26	11/13/63	446
	26	12/4/63	455
	26	12/11/63	424
	26	1/27/64	397
	26	3/24/64	434
	26	6/1/64	413
	27	8/21/63	367
	27	8/21/63	800
IV	27	10/28/63	486
	27	11/18/63	463
	27	12/4/63	417
	27	1/27/64	429
	27	3/30/64	396
	28	8/12/63	605
	28	10/28/63	498
	28	11/18/63	468
	28	12/4/63	420
	28	1/27/64	396
	28	3/30/64	451
	28	6/1/64	349
	29	8/7/63	209
	29	10/31/63	474
	29	11/18/63	487
	29	12/4/63	425
	29	1/27/64	396
	29	3/30/64	399
	47	8/12/63	800
	47	10/28/63	478
	47	11/18/63	470
	47	12/4/63	453
	47	1/27/64	420
	47	3/7/64	384

FIGURE II (Cont'd.)

Summary of Samples by Area and Station

Area #	Station #	Date	Total Wet Weight of Homogenized Sample in Grams
IV	48	8/26/63	397
	48	10/28/63	514
	48	11/18/63	475
	48	12/4/63	451
	48	1/27/64	370
	48	3/24/64	370
	48	6/2/64	400
	49	8/26/63	800
	49	8/26/63	800
	49	10/28/63	498
	49	11/18/63	469
	49	3/23/64	424
	49	6/1/64	380
	51	10/28/63	504
	51	11/18/63	510
	51	12/4/63	479
	51	1/22/64	458
	51	3/23/64	424
	51	6/1/64	354
	52	10/28/63	489
	52	11/18/63	441
	52	12/4/63	435
	52	1/27/64	417
	52	3/24/64	403
V	13	10/29/63	415
	13	11/13/63	347
	13	1/22/64	213
	13	3/23/63	434
	13	6/1/64	412
	14	8/26/63	333
	14	10/29/63	491
	14	11/13/63	434
	14	12/3/63	437
	14	1/22/64	416
	14	3/23/64	409
	14	6/1/64	409
	15	8/26/63	136
	15	10/29/63	428
	15	11/13/64	493
	15	12/3/63	411
	15	1/22/64	413
	15	3/23/64	404
	15	6/1/64	312
	16	8/28/63	125
	16	10/29/63	455
	16	11/13/63	475
	16	12/3/63	410
	16	1/22/64	395
	16	3/23/64	387
	16	6/1/64	307

FIGURE II (Cont'd.)

Summary of Samples by Area and Station

Area #	Station #	Date	Total Wet Weight of Homogenized Sample in Grams
V	17	8/26/63	621
	17	10/29/63	484
	17	11/13/63	456
	17	12/3/63	459
	17	1/22/64	384
	17	3/23/64	455
	17	6/1/64	357
	18	10/29/63	477
	18	11/13/63	452
	18	12/3/63	422
	18	1/22/64	388
	18	3/23/64	401
	18	6/1/64	427
	23	8/21/63	430
	23	10/29/63	488
	23	11/13/63	497
	23	11/13/63	429
	23	12/3/63	444
	23	1/22/64	397
	23	1/22/64	399
	23	3/23/64	372
	23	6/1/63	352
	24	8/26/63	473
	24	10/29/63	471

Area #	Station #	Date	Total Wet Weight of Homogenized Sample in Grams
V	24	12/3/63	431
	24	1/22/64	412
	24	3/23/64	412
	24	6/1/64	414
	50	10/29/63	483
	50	12/3/63	436
	50	3/23/63	410

- -

Miscellaneous Station

Station #	Date	Total Wet Weight of Homogenized Sample in Grams
19	8/21/63	475
	8/21/63	677
11	8/28/63	620
73	12/3/63	426
	2/22/64	400
	6/1/64	397

II. Analytical Procedure:

One hundred grams of drained, homogenized clam tissue is lyophilized for 15 hours. The sample is ground to a powder and extracted as in the original procedure.

A 100 gram wet-weight equivalent of the lyophilized sample is weighed into a 800 ml. beaker. Extract once with 300 ml. and repeat with 200 ml. of hot $CHCL_3$. Heat with stirring on a steam bath to effect extraction. Filter each portion through fluted filter paper into a 600 ml. beaker. Evaporate extracts to a small volume on a steam bath with the use of air. Transfer to a small tared beaker. Evaporate solvent and dry oil to constant weight at 100°C.

Preparation of column. Pack pledget of glass wool in the constricted end of a glass column. A constant weighed amount of dry alumina is placed in the column. The column is packed by using an electric vibrator for 4 minutes during filling to insure uniform and consistent results. The surface of the alumina is covered with a disc made from any rapid flow filter paper, making it slightly smaller than the inside of the column. Wash with 50 5 ml. portions of petroleum ether. Shut off the flow just before the last washing settles in the alumina.

Separation of Unsaponifiables. The weighed and extracted oil from the original sample is dissolved in petroleum ether in a small beaker. This is carefully placed on the alumina column. The stopcock is opened and the eluate is collected at a rate not to exceed 5 ml/minute. The stopcock is closed when ether-oil mixture reaches the surface of the alumina. The beaker is rinsed with 2-3 mls. of petroleum ether, pouring each rinse on the column so that the sides are washed down. Again the stopcock is opened and the ether is allowed to settle to the alumina surface. The column is filled with petroleum ether and 100 mls. of eluate is collected at the rate of 5 ml/minute. The petroleum ether is concentrated to a small volume and transferred quantitatively to a tared beaker. Evaporate to dryness at 100°C and calculate the percent of unsaponifiables. The results are given as mgms per 100 grams of tissue homogenate.

The residual oil is transferred to NaCl plates and the IR spectrum is run. This is compared with a standard USP mineral oil. If volume is too small, it is transferred with the aid of CS_2. Peaks should be present at 3.4, 6.82, and 7.25.

Analysis of Total Phenols

Total phenols were determined by the method of Swain and Hillis (6) with certain NERC modifications.

I. Preparation:

A. Reagents

1) Folin-Denis Reagent: To 750 ml. of H_2O, add 100 g. Sodium Tungstate, 20 g. phosphomolybdic acid and 50 ml. phosphoric acid. Reflux 2 hours, cool, dilute to 1 liter.

B. Extraction

Lyophilize 15 gram sample of drained homogenized clam tissue for 16 hours. The 15 gram wet-weight equivalent of material is extracted with five 50 ml. portions of methanol. The extract is filtered through #1 Whatman paper into a 250 ml. volumetric flask and made up to volume.

II. Analytical Procedure:

Twenty ml. of distilled water is introduced into a 25 ml. volumetric flask. To this 0.5 ml. of the methanol extract is added and mixed well. Add 1.25 ml. of Folin-Denis reagent and mix thoroughly. Exactly three minutes later 2.5 ml. of 1.5M sodium carbonate solution is added and mixed. The solution is diluted to volume, and mixed and set in a 30°C constant temperature bath for 50 minutes. After 50 minutes it is read on a DU spectrophotometer in a 1 cm cell at 725 mu. Results are read from a standard curve and calculated as mgms per 100 grams of original tissue homogenate.

Pesticide Analysis

Gas liquid chromatographic techniques were used for the analysis of Lindane, Aldrin, and Dieldrin in shellfish for this study, with NERC modifications of techniques developed by Mills (7, 8). The sample is stripped, saponified, extracted, and clean-up via either column chromatography (Florisil, etc.) or solvent partitioning (acetonitrile, etc.).

Procedure:

Ten grams of shellfish tissue homogenate is extracted with hexane and saponified with 20 ml. of alcoholic KOH on a steam bath for 15-20 minutes. The material is cooled and extracted quantitatively with 10 ml. of hexane. This extract is dried with anhydrous sodium sulfate and cleaned up if necessary via solvent partition with acetonitrile or on a Florisil column. The final hexane extract is sealed in glass ampoules and held for analysis on a Perkin-Elmer Gas Chromatograph Model #800 with electron capture detector using Chromosorb W and silicone gum rubber. The unknowns were quantitated with pesticide analytical standards. The results are calculated on the basis of ppm of the original tissue homogenate.

Metals

The metals in this study were determined by a method developed at NERC making use of atomic absorption spectrophotometry(9). The metals zinc, chromium, nickel, lead, and copper were determined by wet-ashing 5 gram samples of shellfish homogenate in 125 ml. Erlenmeyer flasks using 1.1 mixture of concentrated nitric and perchloric acids with heat, such that the reaction temperature of the mixture never exceeded 100°C. The resultant mixture was diluted to 100 ml. with conductivity water and read on a Perkin-Elmer Atomic Absorption Spectrophotometer, Model #303. The readouts for each unknown were quantitated by means of a similarly prepared metal standard. The results are reported as mgms per killo of the original tissue homogenate.

Results and Discussion

In order to properly assess the analytical data from this study, it was deemed necessary to develop a normal comparative pattern which could be used to evaluate the experimental results. Comparable data in the literature for these particular contaminants in shellfish are either non-existent, or out-dated methods-wise. It was therefore decided to collect a representative group of "normal" shellfish samples from chemically and biologically clean areas and to analyze for those compounds and metals under study. The resulting data served as our baseline values and were used as "normal" levels in evaluating the Raritan Bay analyses. These values are shown in Table I.

TABLE I

NERC Base Line Values

Trace Metals Mg./Kilo tissue	Phenols Mg./100 gms tissue	Mineral Oils Mg./100 gms tissue	Pesticides PPM
Cu 0 - 5 mg.	35.2	0 - 4	Aldrin 0
Zn 40 -60 mg.			Dieldrin 0
Pb 0 -.3 mg.			Lindane 0
Cr 0 -.2 mg.			
Ni 0 -.2 mg.			

The complete experimental data of this study are summarized in Figure III and more specifically are illustrated throughout this report in the various accompanying plates.

Results and Discussion

Phenols

The phenol data are summarized in Plates I and II. The average station values within the areas studied, arranged according to seasons of collection, are illustrated in the map on Plate I. There appear to be no significant differences between the warm and cold weather samples within the period studied. The values range from 38.0 to 100 mg./100 grams of tissue. The station and area averages are shown in Plate 2. Area I contained the greatest number of analyzed stations (eight), due to the fact that this area was considered to be one of the three highly indicative of possible contaminant accumulation. The station levels within this area range from 53.6 to 76.0 mg./100 grams of tissue, with an Area I average of 63.7. Area II contained two stations giving an average value of 55.5. Areas III through V contributed the highest values with averages of 73.3, 65.5, and 72.0, respectively. All five areas within the bay resulted in an overall value of 66.0 mg./100 grams wet tissue. In comparing these results with our baseline value of 35.2, we find an 88% increase in the overall phenol values when compared with the normal, for those areas studied.

The levels in those sections of the bay studied are almost double our normal phenol value and perhaps represent a certain degree of pollution in these particular areas.

FIGURE III

Summary of Analytical Chemical Data on Raritan Bay

Area #	Station #	Collection Date	Trace Metals (Mgms/Kilo) Cu	Zn	Pb	Cr	Ni
I	2	8-12-63	6.4	43.0	3.0	0.0	1.8
	2	11-5-63	10.2	47.0	1.6	0.0	3.8
	2	3-24-63	7.0	55.0	3.6	0.8	3.1
	4	11-5-63	8.0	51.0	5.4	0.4	2.1
	4	8-12-63	7.4	47.0	2.2	0.0	1.8
	4	3-31-64	7.4	60.0	3.0	1.4	1.4
	4	8-13-64	9.4	84.5	3.5	0.0	1.0
	30	8-7-63	7.2	66.0	3.5	0.7	1.8
	30	11-6-63	8.0	52.0	1.6	0.4	5.0
	31	8-7-63	7.6	50.0	7.3	0.6	6.0
	31	11-6-63	8.8	53.0	3.0	0.8	3.1
	31	3-30-64	8.4	55.0	3.6	0.8	2.1
	31	8-19-64	8.4	42.0	3.6	0.0	4.2
	41	8-13-64	8.2	78.0	6.6	0.0	2.6
	41	8-21-63	9.4	52.0	6.6	0.0	4.5
	41	11-5-63	9.4	63.0	5.8	0.0	3.6
	41	3-16-64	7.2	52.0	5.8	0.0	4.0
	42	8-19-63	7.2	64.0	6.0	0.0	3.1
	42	11-5-63	6.4	38.0	6.0	0.0	3.9
	42	3-24-64	6.2	50.0	6.6	0.7	3.1
	42	8-18-64	7.6	71.0	4.9	0.0	4.5
	43	11-5-63	6.8	32.0	3.5	0.0	4.0
	43	3-24-64	3.6	39.0	6.0	0.0	3.1
	43	8-19-64	7.0	43.0	3.6	0.0	2.8
	44	11-6-63	6.6	44.0	6.4	2.0	4.0
	44	3-30-64	7.4	52.0	5.0	1.5	4.0
	44	8-19-64	7.0	54.0	3.5	2.0	3.0
II	7	8-28-63	5.4	69.6	5.5	0.0	3.0
	7	11-4-63	10.4	87.6	3.3	2.8	3.0
	7	3-23-63	6.6	88.4	4.7	0.0	3.2
	7	8-13-64	8.4	118.6	4.3	0.0	1.8
	40	11-5-63	68.1	2.0	0.0	1.8	
	40	3-31-64	6.6	27.0	2.2	0.9	4.3
	40	8-13-64	6.2	72.0	2.3	1.3	0.0

FIGURE III (Cont'd.)

Summary of Analytical Chemical Data on Raritan Bay

Area #	Station #	Collection Date	Pesticides (PPM)			Phenols (Mgms/100 Gms)	Mineral Oil (Mgms/100 Gms)
			Aldrin	Dieldrin	Lindane		
I	2	8-12-63	-	-	-	67.0	7.82
	2	11-5-63	<.01	-	-	71.0	
	2	3-24-64	-	-	-	47.0	
	4	11-5-63	-	-	-	65.0	0.3
	4	8-12-63	-	<.01	<.01	70.0	
	4	3-31-64	-	-	-	41.5	
	4	8-13-64	-	-	-	48.0	4.08
	30	8-7-63	-	-	-	49.0	
	30	11-6-63	-	<.01	-	68.0	
	31	8-7-63	-	-	-	100.5	
	31	11-6-63	-	<.01	-	50.0	
	31	3-30-64	<.01	-	<.01	40.5	
	31	8-19-64	-	-	-	50.0	
	41	8-13-64	<.01	<.01	-	81.5	
	41	8-21-63	<.01	<.01	-	60.0	0.75
	41	11-5-63	-	<.01	<.01	83.5	0.24
	41	3-16-64	<.01	-	-	79.0	
	42	8-19-63	-	<.01	-	70.0	4.17
	42	11-5-63	-	<.01	-	73.0	1.91
	42	3-24-64	-	-	-	68.5	
	42	8-18-64	<.01	-	-	75.0	
	43	11-5-63	<.01	-	-	56.5	0.72
	43	3-24-64	-	<.01	-	72.5	3.46
	43	8-19-64	-	-	-	75.0	
	44	11-6-63	-	-	-	62.5	4.45
	44	3-30-64	<.01	-	-	52.0	
	44	8-19-64	-	-	-	53.5	
II	7	8-28-63	-	-	-	55.5	0.1
	7	11-4-63	-	-	-	66.5	
	7	3-23-64	-	-	-	43.0	1.7
	7	8-13-64	-	-	-	44.0	
	40	11-5-63	-	0.01	-	39.0	0.2
	40	3-31-64	-	-	-	65.5	
	40	8-13-64	-	-	-	75.0	

FIGURE III (Cont'd.)

Summary of Analytical Chemical Data on Raritan Bay

Area #	Station #	Collection Date	Trace Metals (Mgms/Kilo)				
			Cu	Zn	Pb	Cr	Ni
III	46	10-31-63	9.4	64.0	3.5	1.4	4.5
	46	8-18-64	6.3	36.6	2.8	0.0	2.9
	56	10-31-63	7.3	53.0	4.4	0.0	2.7
	56	3-30-64	6.5	35.0	4.2	0.0	2.0
	56	8-19-64	6.8	53.0	3.3	0.0	2.4
	57	11-6-63	4.2	66.0	4.2	0.0	3.0
	57	3-30-64	4.6	74.0	4.6	0.0	4.2
	57	8-19-64	7.7	47.0	3.4	0.0	4.0
	61	11-6-63	9.8	76.6	5.0	0.0	4.2
	61	8-19-64	8.1	77.2	6.1	0.0	1.9
	61	3-30-64	7.7	90.6	2.7	0.0	1.7
IV	22	8-21-63	7.2	70.3	2.4	0.0	2.4
	22	10-28-63	5.9	43.1	3.3	0.0	2.0
	22	8-21-63	8.5	67.3	2.5	0.0	2.0
	22	3-16-64	6.6	59.1	2.7	0.0	2.6
	22	8-18-64	7.0	44.0	0.5	0.0	2.0
	28	8-12-63	3.9	48.2	0.7	0.0	2.8
	28	3-30-64	7.0	47.4	2.2	0.0	2.3
	28	10-28-63	6.8	45.3	1.9	0.0	2.7
	48	8-26-63	7.2	73.2	3.3	0.0	2.9
	48	10-28-63	7.3	49.7	1.6	0.0	2.1
	48	3-24-64	6.4	50.2	2.3	0.0	1.3
	48	8-18-64	8.3	73.2	2.3	2.1	2.6
	52	10-28-63	9.2	83.0	0.0	0.0	3.9
	52	3-24-64	7.4	77.0	3.1	0.0	2.6
	52	8-8-64	8.2	79.0	3.1	0.0	0.0
V	24	8-26-63	4.5	44.4	4.5	0.0	2.5
	24	10-29-63	7.2	77.0	0.3	0.0	3.2
	24	3-23-64	6.0	56.0	2.4	0.0	0.0
	24	8-17-64	10.0	55.0	4.2	0.0	1.8
	50	10-29-63	5.6	54.0	1.0	0.0	2.3
	50	3-23-64	5.0	34.0	1.0	0.0	1.6
	50	8-17-64	5.3	46.0	0.5	0.0	1.0

FIGURE III (Cont'd.)

Summary of Analytical Chemical Data on Raritan Bay

Area #	Station #	Collection Date	Pesticides (PPM)			Phenols (Mgms/100 Gms)	Mineral Oil (Mgms/100 Gms)
			Aldrin	Dieldrin	Lindane		
III	46	10-31-63	-	-	-	61.0	2.3
	46	3-30-64	-	0.05	-	58.0	
	46	8-18-64	-	-	-	78.0	
	56	10-31-63	-	-	-	68.0	
	56	3-30-64	-	-	-	77.0	
	56	8-19-64	-	-	-	85.5	
	57	11-6-63	-	-	-	66.6	1.19
	57	3-30-64	-	-	-	89.0	
	57	8-19-64	-	-	-	64.0	
	61	11-6-63	-	-	-	88.0	8.32
	61	8-19-64	-	-	-	78.5	
	61	3-30-64	-	-	-	65.0	
IV	22	8-21-63(1)	-	-	0.01	92.0	
	22	10-28-63	-	-	0.02	97.0	1.1
	22	8-21-63(2)	-	-	-	70.0	
	22	3-16-64	-	-	-	53.0	0.5
	22	8-18-64	-	0.02	-	52.5	
	28	8-12-63	< .01	-	-	56.6	
	28	3-30-64	-	-	0.04	54.0	
	28	10-28-63	-	-	-	53.5	
	48	8-26-63	-	-	-	66.0	1.7
	48	10-28-63	-	-	-	64.5	
	48	3-24-64	-	-	-	92.0	
	48	8-18-64	-	-	< .01	65.5	
	52	10-28-63	-	0.01	-	74.0	0.7
	52	3-24-64	-	-	-	54.5	
	52	8-18-64	-	0.01	-	38.0	
V	24	8-26-63	< .01	-	-	79.0	3.5
	24	10-29-63	-	-	-	78.0	
	24	3-23-64	-	-	-	75.0	0.9
	24	8-17-64	-	-	0.04	75.5	
	50	10-29-63	-	-	-	72.5	0.1
	50	3-23-64	< .01	-	-	62.5	
	50	8-17-64	-	-	-	61.5	

Mineral Oils

Inasmuch as the method used for the detection of mineral oils requires a considerable amount of sample material, we were necessarily limited as to the number of samples and stations that could be studied within a given area. As a result, in order to obtain sufficient analytical material, it was found necessary to combine samples within certain stations. The results of the mineral oil analyses are shown in Plate 3. The average of all areas was approximately 2 mg./100 grams wet tissue. The greatest concentration was found in Area III with an average of 3.6 and a range of 1.19 to 8.32 mg./100 grams. Area I with the greater number of stations analyzed resulted in a value of 2.8 and a range of .3 to 7.82 mg./100 grams. The average value of Area V is 1.5 with a range of .1 to 3.5 mg./100 grams. The remaining areas (II and IV) gave the lowest values of .67 (range .1 to 1.7) and 1.1 (range .5 to 1.7) respectively. In comparison with the normal range (0 to 4 mg./100 grams) we find that four stations in Area I (40% of total) and one station in Area III (33% of total) exceed this figure. All stations within areas II, IV and V fail to exceed the normal level for mineral oil content. However, in Areas I (60%), III (66%) and V(33%), we find the median of the normal range exceeded by the percentages indicated within the parentheses. These results may indicate a degree of pollution as concerns mineral oils.

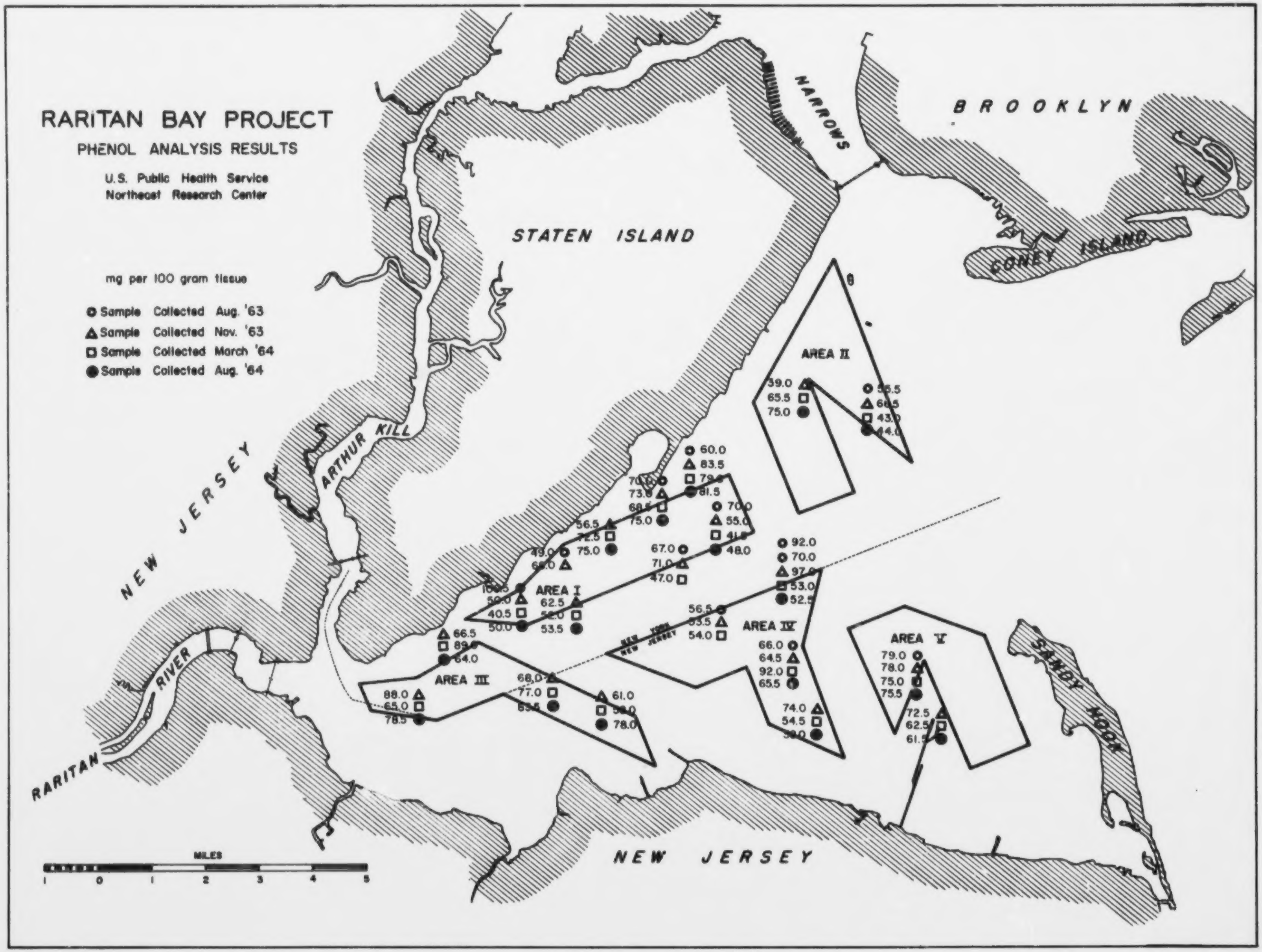
Trace Metals

Chromium

The data for chromium is illustrated in Plates 4 and 5. Here the data are somewhat inconclusive in reference to possible abnormal levels for chromium (Plate 5). In addition, there is no evidence of any significant seasonal variations. (Plate 4). Only two areas (I and II), indicate a questionable elevated chromium level, when compared with the normal range of 0. to .2 mg./100 grams of tissue. Area I and II show average station values of 0.4 and 0.7 mg./100 grams respectively. The possibility of chromium contamination is rather improbable, although 75% (six of eight) of the stations in Area I show values significantly greater than our normal range. All stations (two of two) in Area II resulted in values somewhat higher than normal. It would appear, however, that chromium is not a significant source of contamination in the areas considered and determined through the analysis of shellfish tissue.

Copper

Plates 6 and 7 summarize the data for copper. Plate 6 again indicates that there are no seasonal variations in copper levels. Plate 7 summarizes the area results for copper. All stations exceed the normal baseline range as determined for copper. The area average for copper is 7 mg./100 grams of tissue with a range of 6.2 to 7.6. The survey values are significantly greater by about 50% over the highest levels in our baseline range (Table I). They exceed by 40% the average figures for copper in hard clams, as determined by a recently completed NERC trace metal study of the eastern Atlantic Coast. Although the Bay copper levels may tend to indicate a degree of pollution, they do not indicate that excessive amounts are present, when compared to certain coastal areas where copper is known to be a definite contaminant.


STATEN ISLAND
BROOKLYN
CONEY ISLAND
NARROWS
SANDY HOOK
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW YORK
NEW JERSEY
AREA I
AREA II
AREA III
AREA IV
AREA V
○ 60.0
△ 83.5
□ 79.0
● 81.5
70.0 ○
73.8 △
68.5 □
75.0 ●
○ 70.0
△ 55.0
□ 41.5
● 48.0
56.5 △
72.5 □
75.0 ●
67.0 ○
71.0 △
47.0 □
49.0 ○
66.0 △
100.5 ●
50.0 △
40.5 □
50.0 ●
62.5 △
52.0 □
53.5 ●
39.0 △
65.5 □
75.0 ●
○ 56.5
△ 66.5
□ 43.0
● 44.0
○ 92.0
○ 70.0
△ 97.0
□ 53.0
● 52.5
56.5 ○
53.5 △
54.0 □
66.0 ○
64.5 △
92.0 □
65.5 ●
74.0 △
54.5 □
59.0 ●
△ 66.5
□ 89.0
● 64.0
88.0 △
65.0 □
78.5 ●
68.0 △
77.0 □
53.5 ●
△ 61.0
□ 58.0
● 78.0
79.0 ○
78.0 △
75.0 □
75.5 ●
72.5 △
62.5 □
61.5 ●
MILES
1
0
1
2
3
4
5

RARITAN BAY PROJECT

PHENOL ANALYSIS RESULTS

U.S. Public Health Service
Northeast Research Center

mg per 100 gram tissue

- ○ Sample Collected Aug. '63
- △ Sample Collected Nov. '63
- □ Sample Collected March '64
- ● Sample Collected Aug. '64

GPO 956-592

PLATE I

PHENOL

MG / 100 GRAM TISSUE

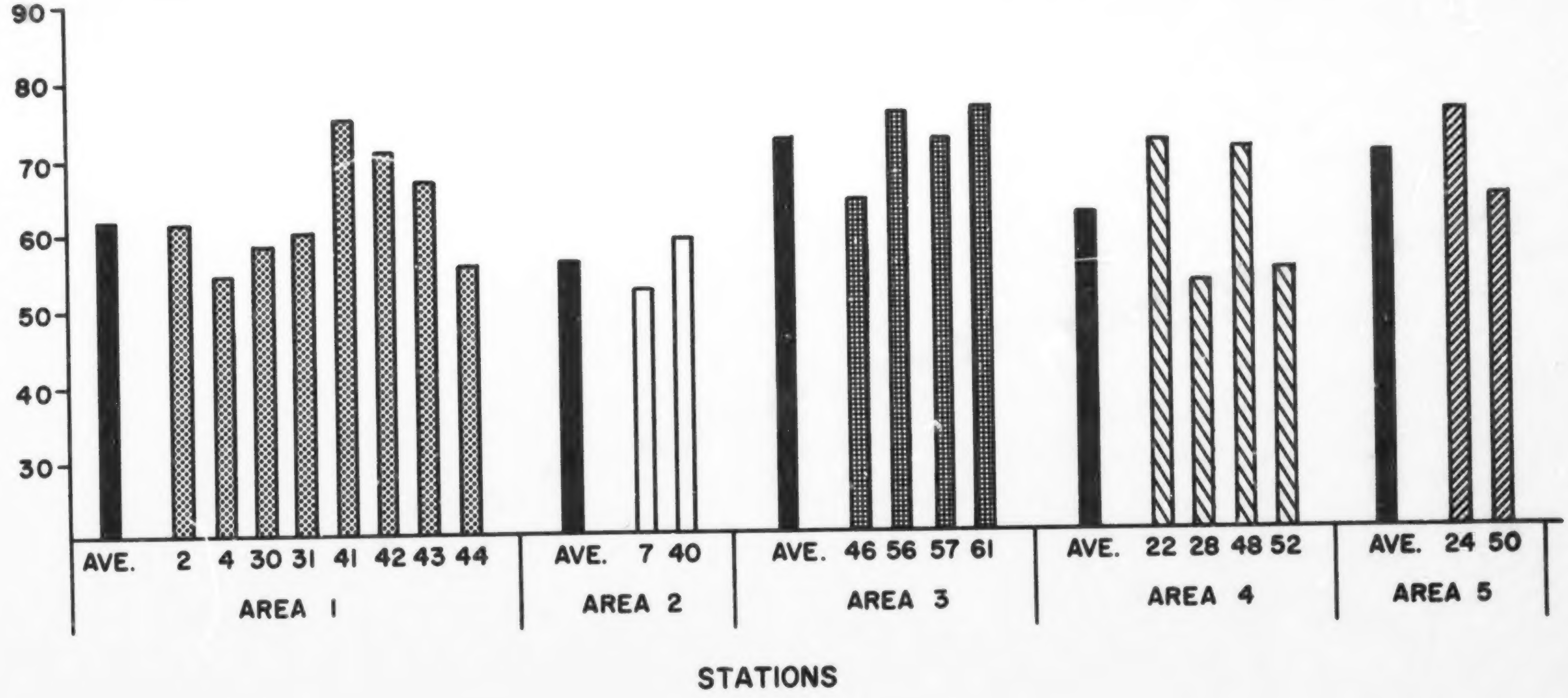


PLATE 2

MINERAL OIL

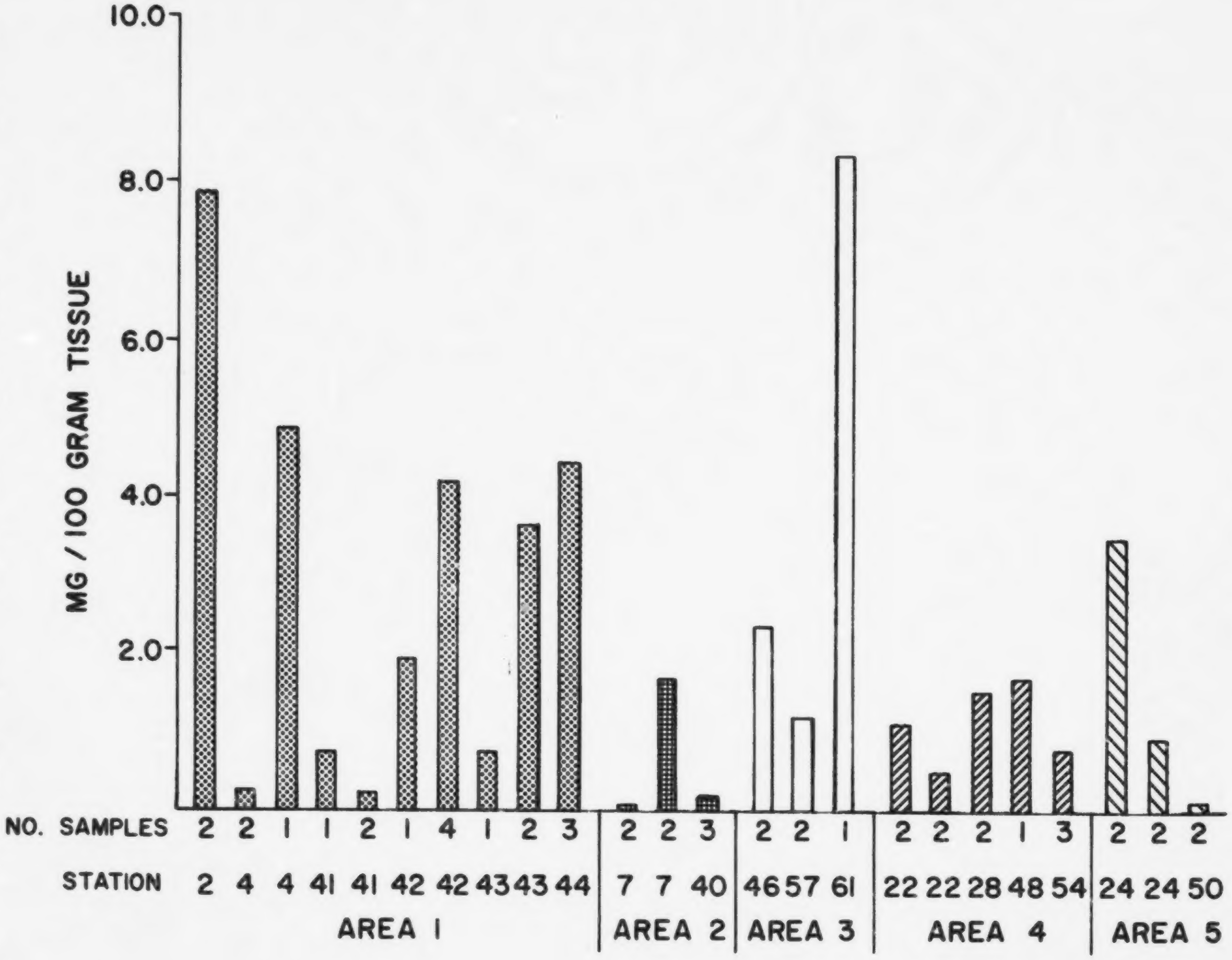
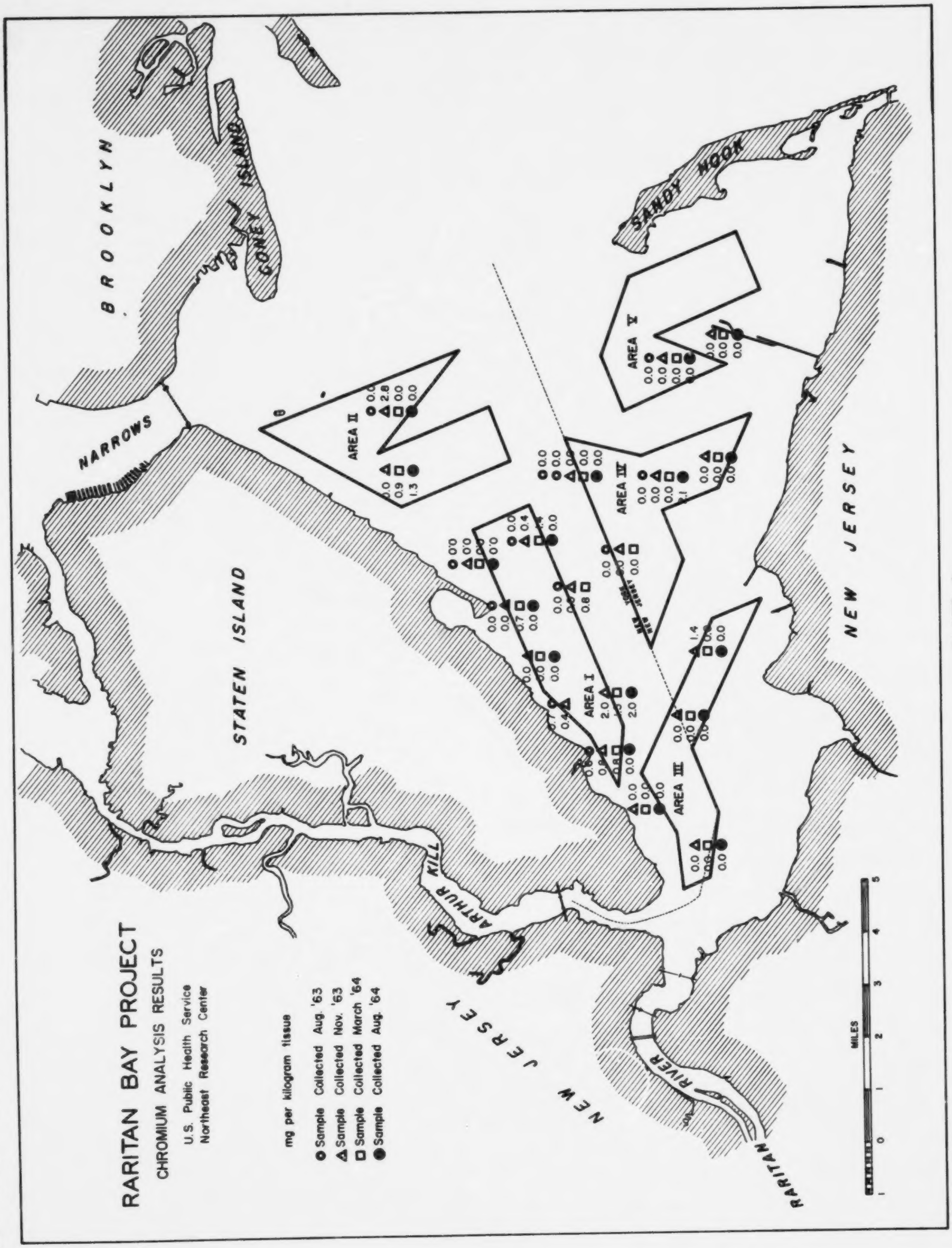


PLATE 3


BROOKLYN
CONEY ISLAND
NARROWS
STATEN ISLAND
SANDY HOOK
NEW JERSEY
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
AREA I
AREA II
AREA III
AREA IV
AREA V
MILES
0
1
2
3
4
5

RARITAN BAY PROJECT

CHROMIUM ANALYSIS RESULTS

U.S. Public Health Service
Northeast Research Center

mg per kilogram tissue

- ○ Sample Collected Aug. '63
- △ Sample Collected Nov. '63
- □ Sample Collected March '64
- ● Sample Collected Aug. '64

PLATE 4

GPO 956-592

CHROMIUM

MG / KILOGRAM TISSUE

0 - NO CHROMIUM DETECTED

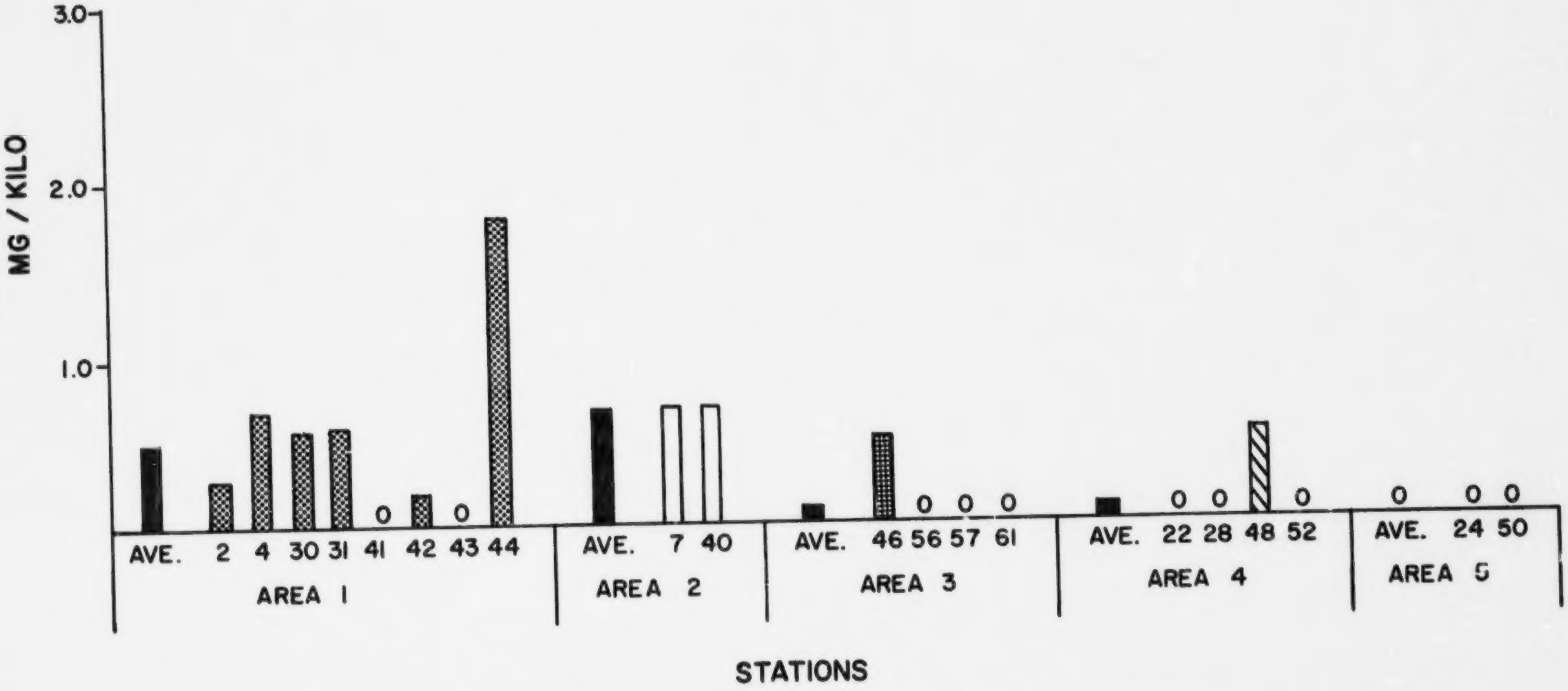
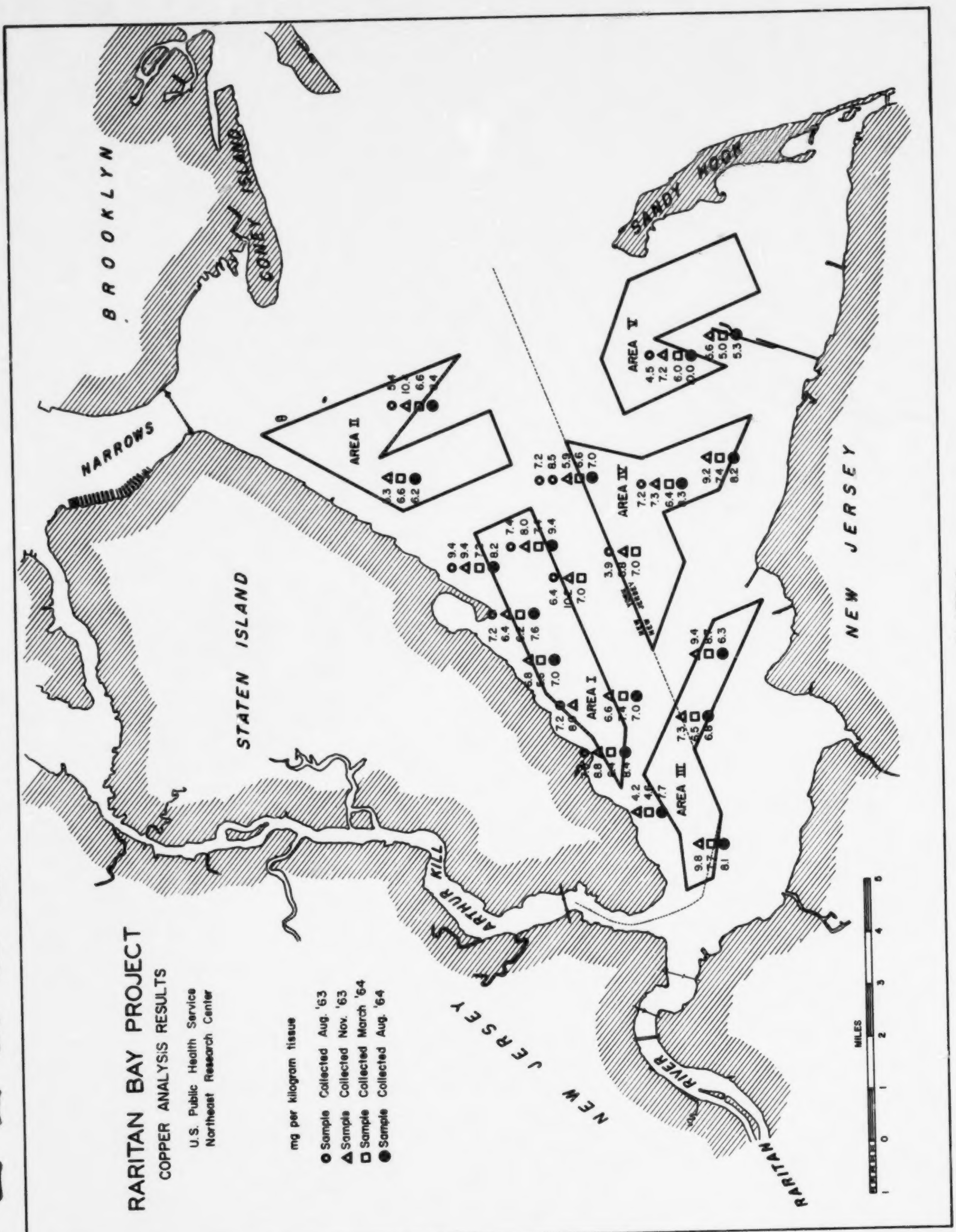


PLATE 5



RARITAN BAY PROJECT
COPPER ANALYSIS RESULTS

U.S. Public Health Service
Northeast Research Center

mg per kilogram tissue

- ○ Sample Collected Aug. '63
- △ Sample Collected Nov. '63
- □ Sample Collected March '64
- ● Sample Collected Aug. '64

BROOKLYN
CONEY ISLAND
NARROWS
STATEN ISLAND
SANDY HOOK
AREA I
AREA II
AREA III
AREA IV
AREA V
ARTHUR KILL
RARITAN RIVER
NEW JERSEY
NEW JERSEY
MILES
0
1
2
3
4
5

PLATE 6

GPO 956-592

COPPER

MG / KILOGRAM TISSUE

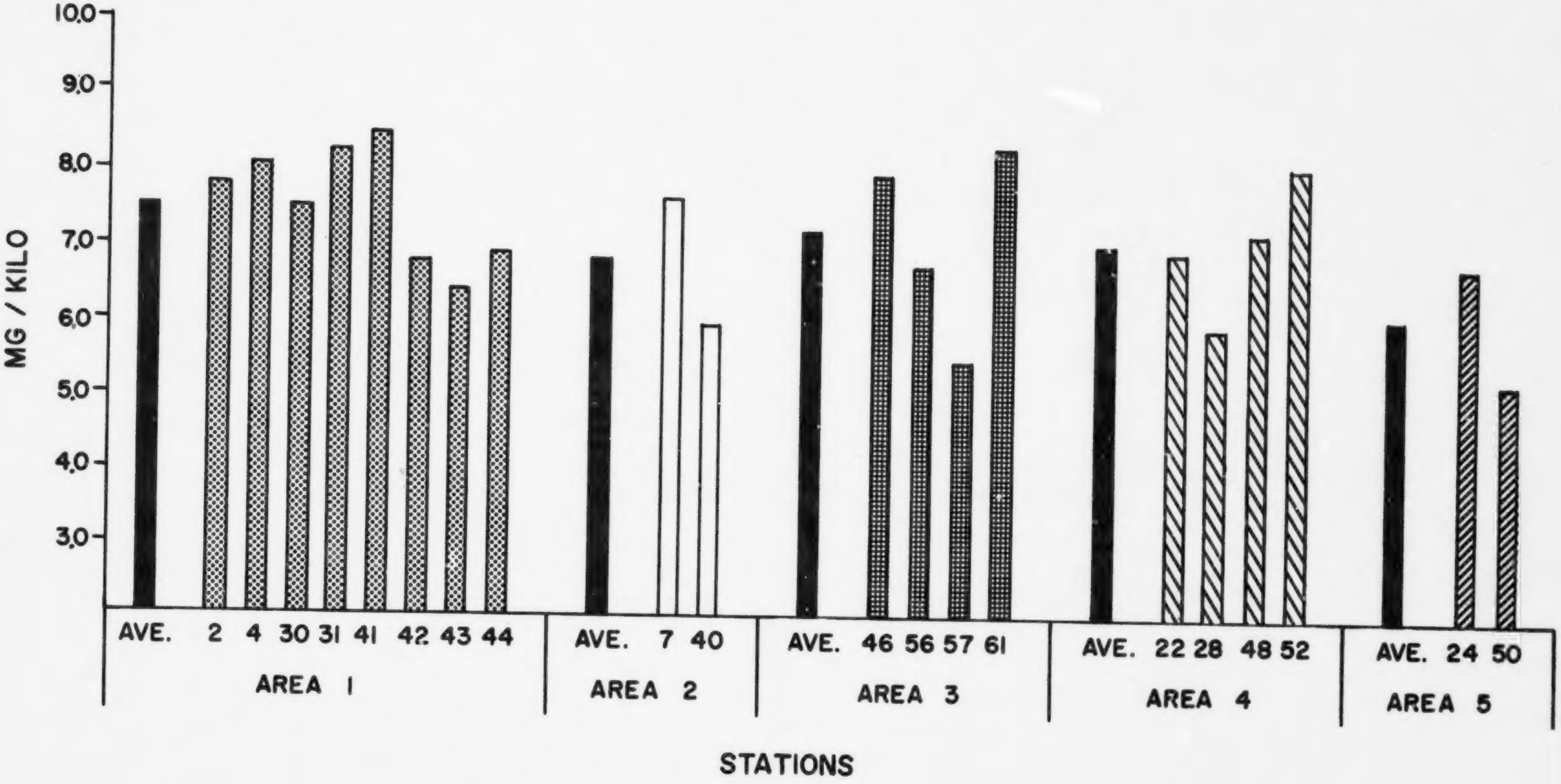


PLATE 7

Lead

Lead values, detected in those sections of the bay studied, proved to be substantially elevated when compared to our normal levels for this particular metal. Plates 8 and 9 summarize the analytical results for lead. In Plate 8 we were unable to observe any cold versus warm weather sample difference. Plate 9 indicates that all stations have lead values exceeding the normal limits by approximately ten times. The area average for lead is 3.2 mg./kilo tissue. The station values range from .8 to 6.2 mg. This is a tenfold elevation when compared to the normal range of 0 to .3 mg. It appears that lead might be considered a pollutant source as regards the area studied. We find that Area V appears here as elsewhere to be the section of least pollution.

Nickel

The results for nickel appear to be about the same as for lead. Every station gave values which were elevated tenfold over normal. The overall average is 2.6 mg./kilo, while the results range from 1.8 to 3.2 mg. The data for nickel are summarized in Plates 10 and 11. Consistent with all our other data, the seasonal levels shown in Plate 10 again indicate that no warm and cold weather relations appear to exist as regards shellfish tissue for those contaminants studied. Here again, although elevated, we find lower station values for nickel in Area V.

Zinc

Zinc data are illustrated in Plates 12 and 13. As has been the case throughout this study, we have been unable to detect any significant variations between warm and cold weather sampling. This pattern holds for the zinc levels as well and is shown in Plate 12. The station averages indicate values in the upper range of normal, but no significant elevations were noted. Plate 13 indicates that Area averages range from 50.8 to 75.9mg./kilo tissue. The overall area average is approximately 61 mg. which is at the uppermost limits of our normal range of values (40-60 mg./ kilo) shown in Table I. Therefore, it appears that zinc levels as found in shellfish tissue do not appear to be a significant contaminant within the bay areas studied.

Pesticides

In the co-operative experimental design of this study, it was decided that the three pesticides proposed to be studied would probably be most indicative for this particular area as regards such a group of organic contaminants. The compounds selected were Aldrin, Dieldrin and Lindane, which are exceptionally persistent in the environment in which released, because of their chemical structure (chlorinated hydrocarbons). The pesticide data are illustrated in Plate 14. All Area I stations were positive for at least one of the three pesticides studied, although no station gave values greater than .01 ppm. All samples in this area were positive for all of the eight stations analyzed. Twenty of a total of twenty-seven samples were positive for one of the three pesticides surveyed. Ten samples out of thirty resulted in values of .02 to .05 ppm for these same three pesticides in Areas II through V. The remaining positive samples in these four areas were of levels of less than .01 ppm. Out of a total of 68 samples 33 proved to be positive for one of these particular compounds. It appears that these materials are finding their way into the bay areas studied and are being picked up with probable concentration by shellfish within this environment.

Summary

1. Sixty-nine representative shellfish samples out of some four hundred collected were studied to ascertain the possible presence of certain trace metals, and organic materials (phenols, mineral oils and pesticides), which had been agreed upon as possibly being indicative of contaminant sources within the areas of the Raritan Bay being studied.

2. These sixty-nine samples from twenty stations within the five areas were selected on the basis of shellfish source and currents.

3. The phenol values within the areas studied appear to be significantly elevated when compared with the normal values.

4. The results of mineral oils analyses may possibly indicate some degree of pollution.

5. The copper levels, although somewhat elevated compared with the normal baseline values, do not appear to indicate any gross contamination.

6. Lead appears to be a possible contaminant source in all areas studied. The values are approximately tenfold higher than normal.

7. The nickel levels run almost parallel with lead as a contaminant source, inasmuch as values for this particular metal were also found to be at least ten times those of the normal baseline results.

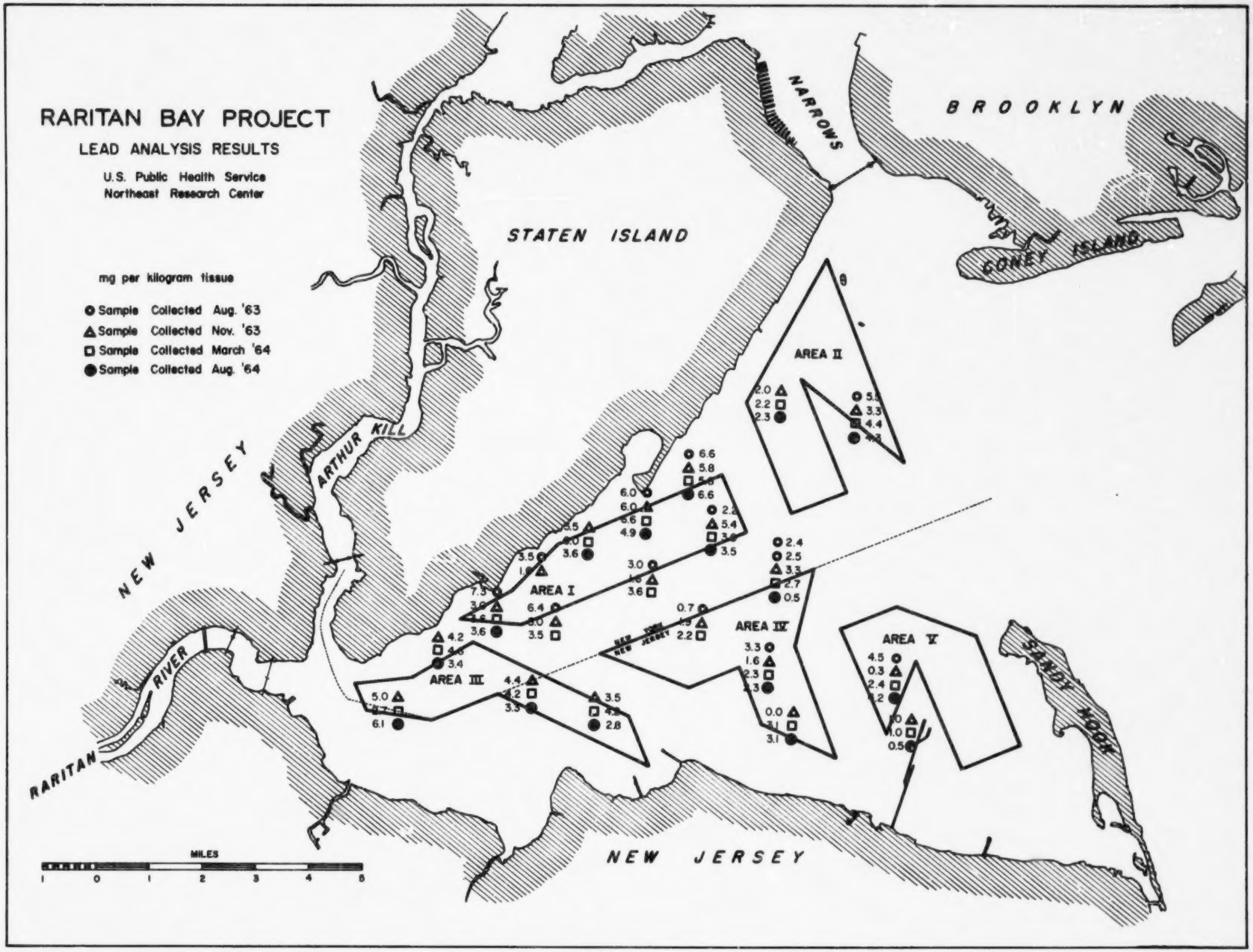
8. Zinc, with values falling within the upper level of the normal range, does not appear elevated and probably does not represent a contaminant source for shellfish in these areas.

9. Chromium results in general are not indicative of a contaminant source role for this particular metal within any of the five areas studied. Levels were found to be within the normal range with the exception of Areas I and II. In these particular areas, the levels did not approach values to lend any credence to chromium being a possible pollutant.

10. The fact that at least one of the three pesticides under study were detected in every area, does indicate the possibility that these materials may be contributing to pollution within the areas studied.

11. Analytical results within Area V indicate that there probably is less contamination here than in the remaining sections surveyed.

12. All other sections vary as to the degree of contamination, while Areas I and II indicate pollution of greater significance for those materials studied.


RARITAN BAY PROJECT
LEAD ANALYSIS RESULTS
U.S. Public Health Service
Northeast Research Center
mg per kilogram tissue
○ Sample Collected Aug. '63
△ Sample Collected Nov. '63
□ Sample Collected March '64
● Sample Collected Aug. '64
BROOKLYN
CONEY ISLAND
NARROWS
STATEN ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
SANDY HOOK
NEW JERSEY
NEW YORK
NEW JERSEY
AREA I
AREA II
AREA III
AREA IV
AREA V
7.3
3.6
3.5
1.6
3.6
6.4
3.0
3.5
6.0
6.0
6.6
4.9
6.6
5.8
6.6
2.2
5.4
3.5
3.0
3.6
2.0
2.2
2.3
5.5
3.3
4.4
2.4
2.5
3.3
2.7
0.5
0.7
2.2
3.3
1.6
2.3
0.0
3.1
4.5
0.3
2.4
1.0
0.5
4.2
3.4
5.0
6.1
4.4
3.3
3.5
2.8
MILES
1
0
1
2
3
4
5

GPO 956-592

PLATE 8

LEAD

MG / KILOGRAM TISSUE

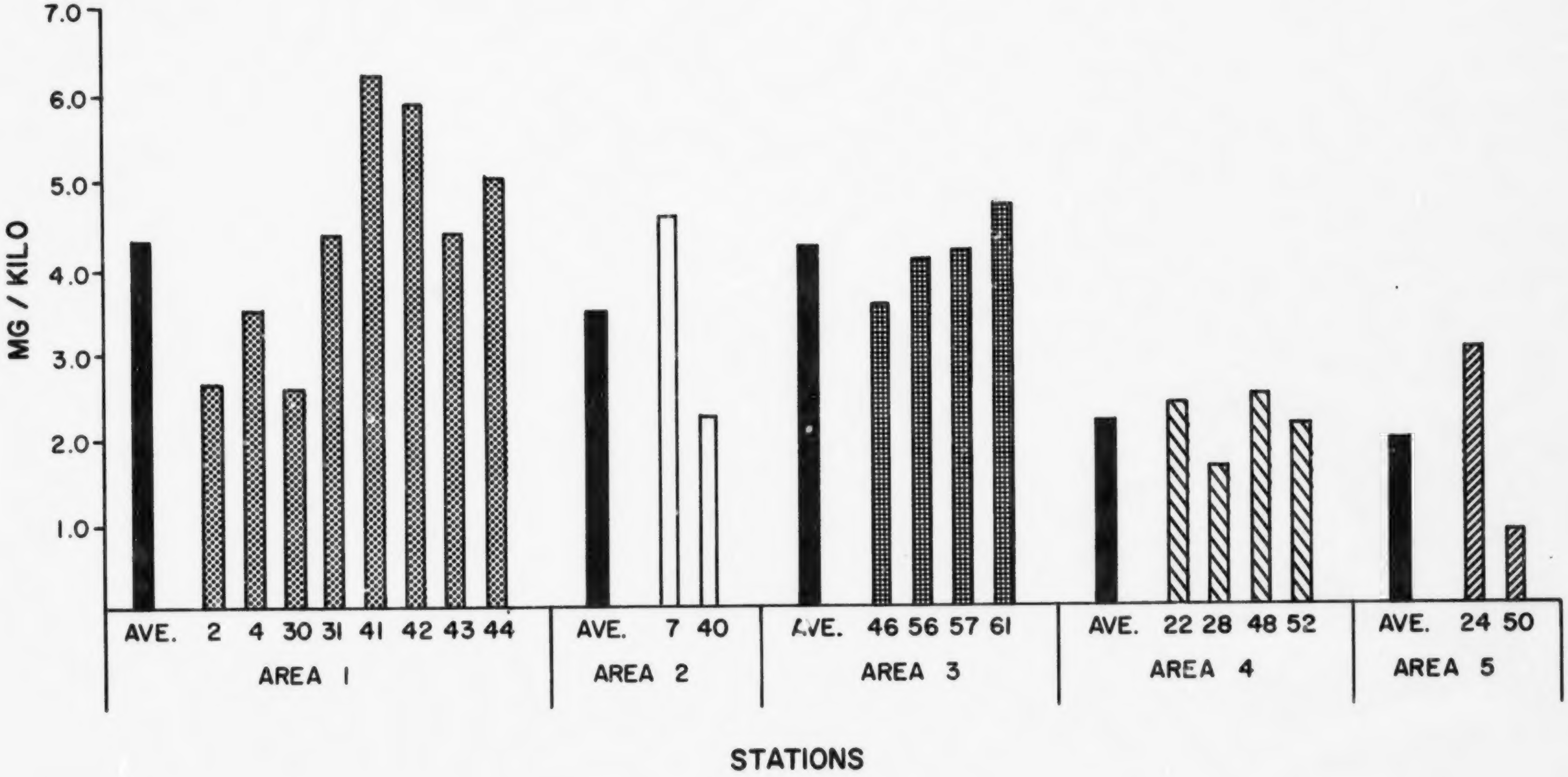
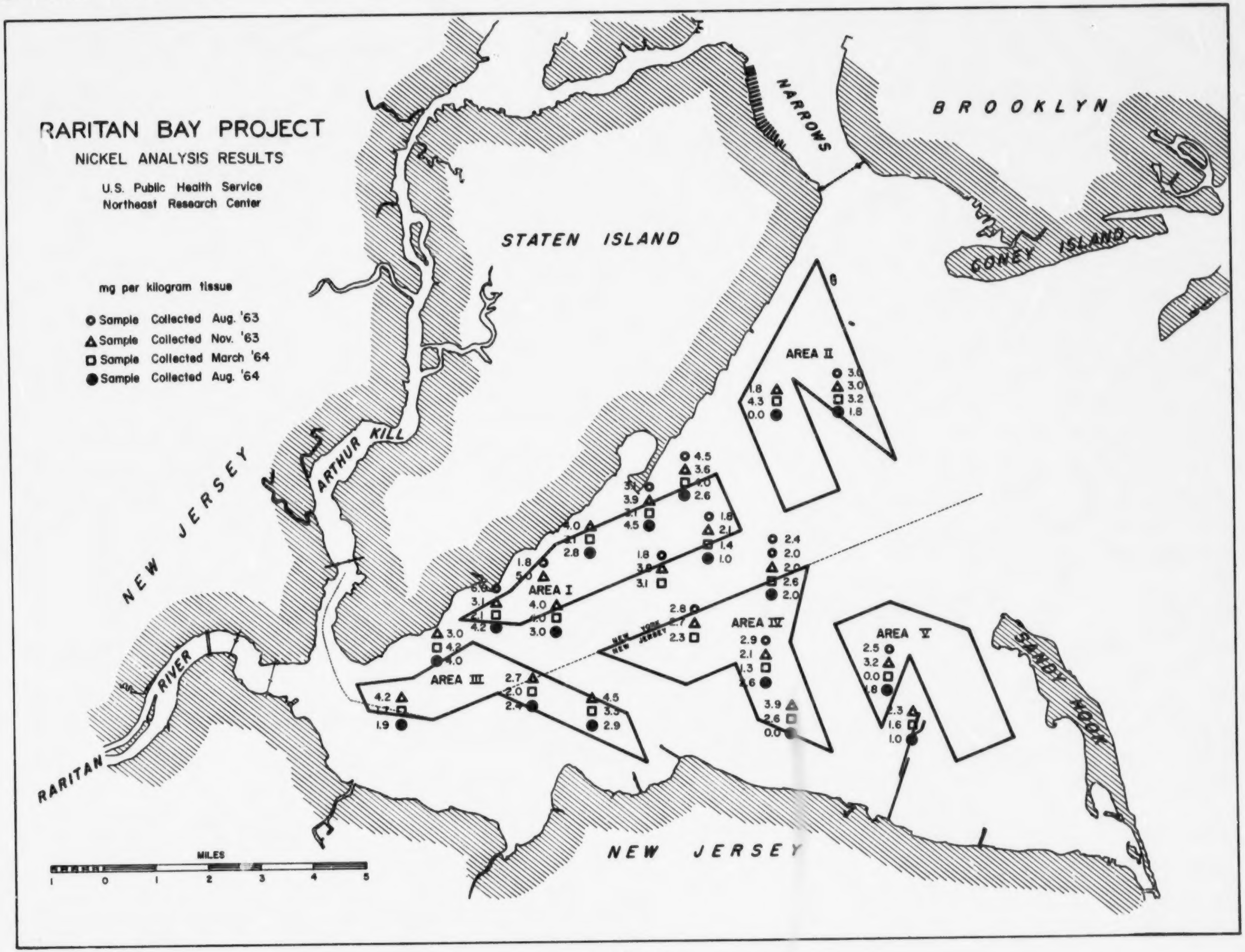


PLATE 9


RARITAN BAY PROJECT
NICKEL ANALYSIS RESULTS
U.S. Public Health Service
Northeast Research Center
mg per kilogram tissue
○ Sample Collected Aug. '63
△ Sample Collected Nov. '63
☐ Sample Collected March '64
● Sample Collected Aug. '64
STATEN ISLAND
BROOKLYN
NARROWS
CONEY ISLAND
SANDY HOOK
NEW JERSEY
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW YORK
NEW JERSEY
AREA I
AREA II
AREA III
AREA IV
AREA V
1.8
4.3
0.0
3.0
3.0
3.2
1.8
4.5
3.6
4.0
2.6
3.1
3.9
3.1
4.5
1.8
2.1
1.4
1.0
4.0
2.1
2.8
1.8
3.9
3.1
1.8
5.0
6.0
3.1
2.1
4.2
4.0
4.0
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2.4
2.0
2.0
2.6
2.0
2.8
2.7
2.3
2.9
2.1
1.3
2.6
3.9
2.6
0.0
2.5
3.2
0.0
1.8
2.3
1.6
1.0
3.0
4.2
4.0
2.7
2.0
2.4
4.5
3.5
2.9
4.2
1.9
MILES
1
0
1
2
3
4
5

PLATE 10

GPO 956-592

NICKEL

MG / KILOGRAM TISSUE

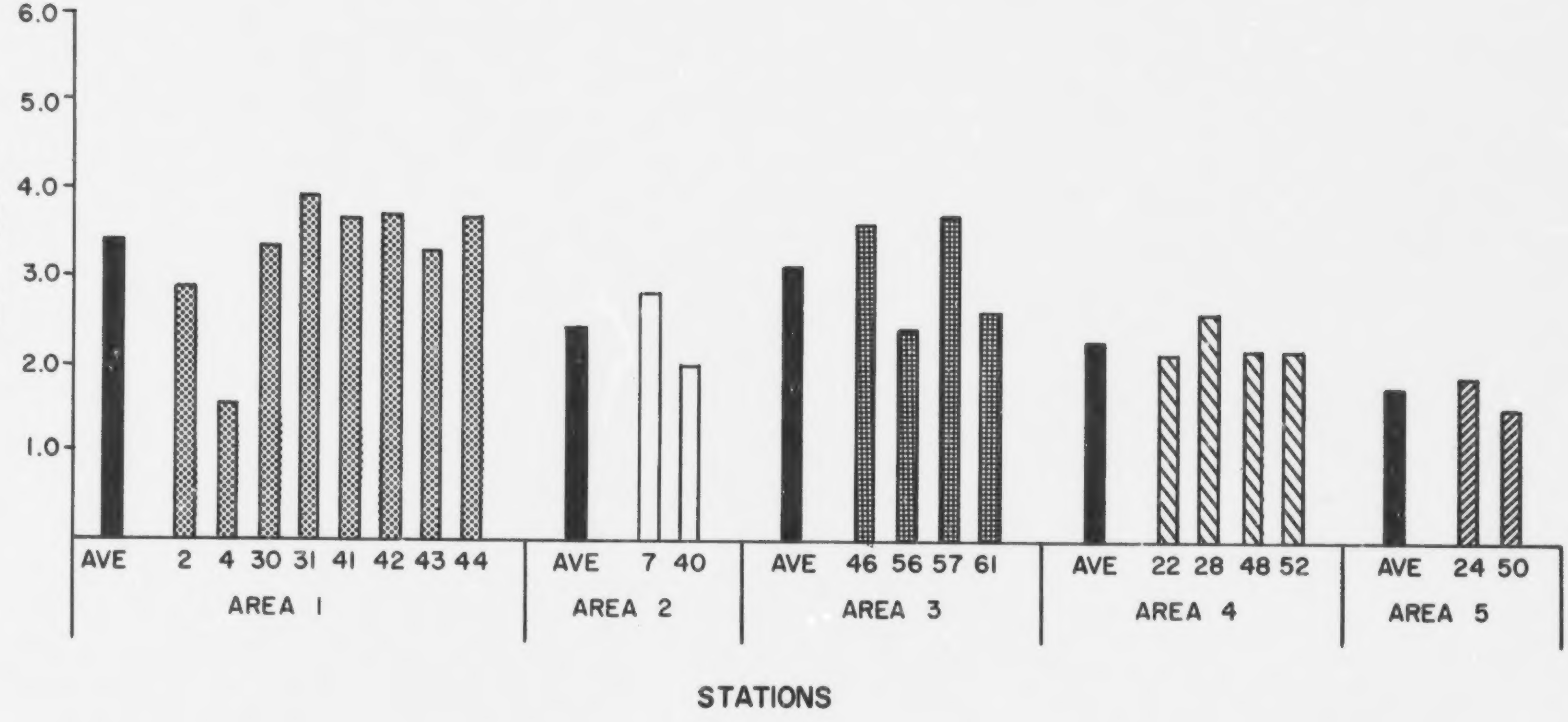
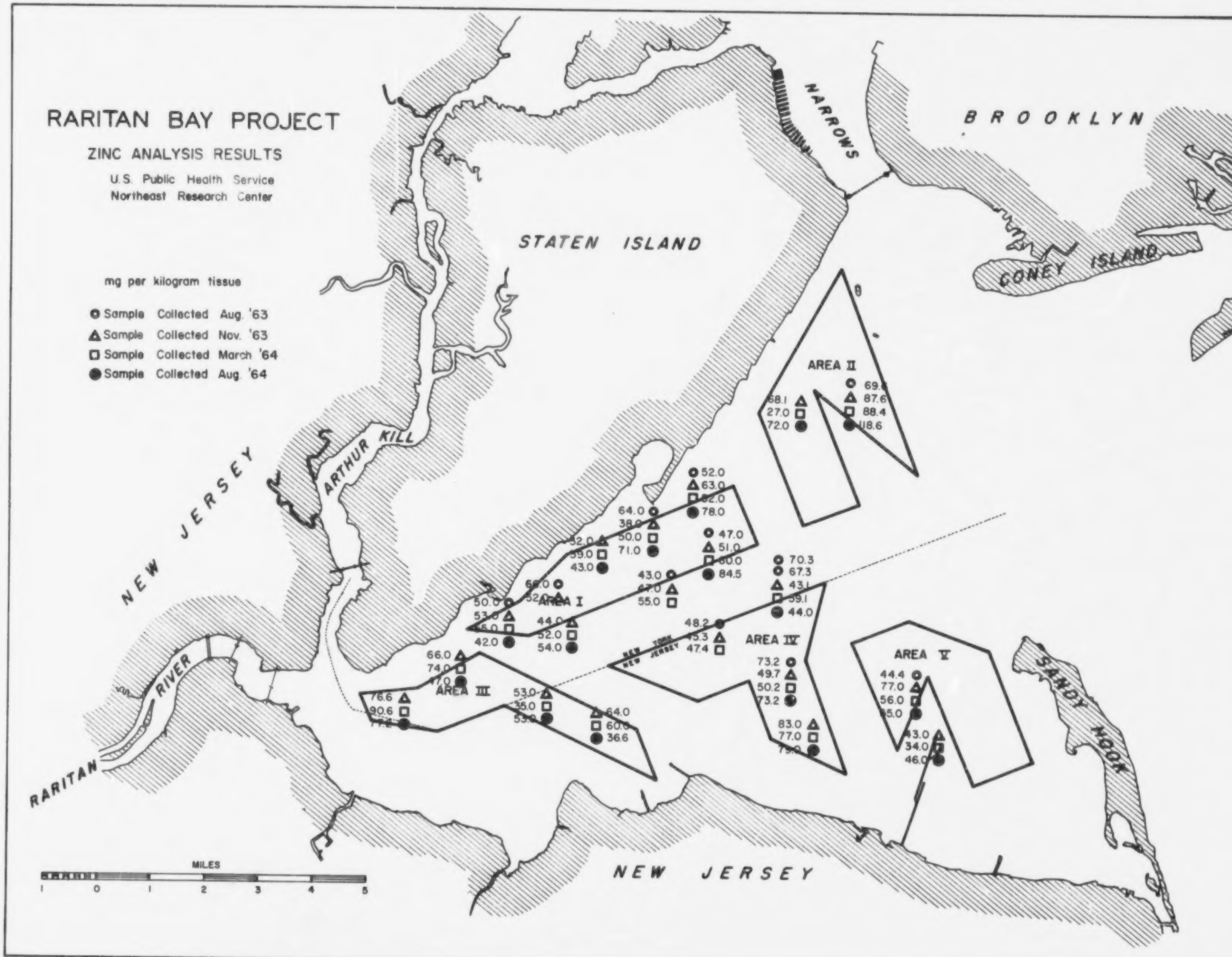


PLATE II


RARITAN BAY PROJECT
ZINC ANALYSIS RESULTS
U.S. Public Health Service
Northeast Research Center
mg per kilogram tissue
○ Sample Collected Aug. '63
△ Sample Collected Nov. '63
□ Sample Collected March '64
● Sample Collected Aug. '64
STATEN ISLAND
BROOKLYN
CONEY ISLAND
NARROWS
SANDY HOOK
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW JERSEY
NEW YORK
NEW JERSEY
AREA I
AREA II
AREA III
AREA IV
AREA V
50.0
53.0
56.0
42.0
66.0
52.0
44.0
52.0
54.0
32.0
39.0
43.0
64.0
38.0
50.0
71.0
43.0
67.0
55.0
52.0
63.0
62.0
78.0
47.0
51.0
60.0
84.5
68.1
27.0
72.0
69.8
87.6
88.4
118.6
66.0
74.0
77.0
76.6
90.6
77.2
53.0
35.0
53.0
64.0
60.0
36.6
48.2
45.3
47.4
70.3
67.3
43.1
59.1
44.0
73.2
49.7
50.2
73.2
83.0
77.0
79.0
44.4
77.0
56.0
55.0
43.0
34.0
46.0
MILES
1
0
1
2
3
4
5

GPO 956-592

PLATE 12

ZINC

MG / KILOGRAM TISSUE

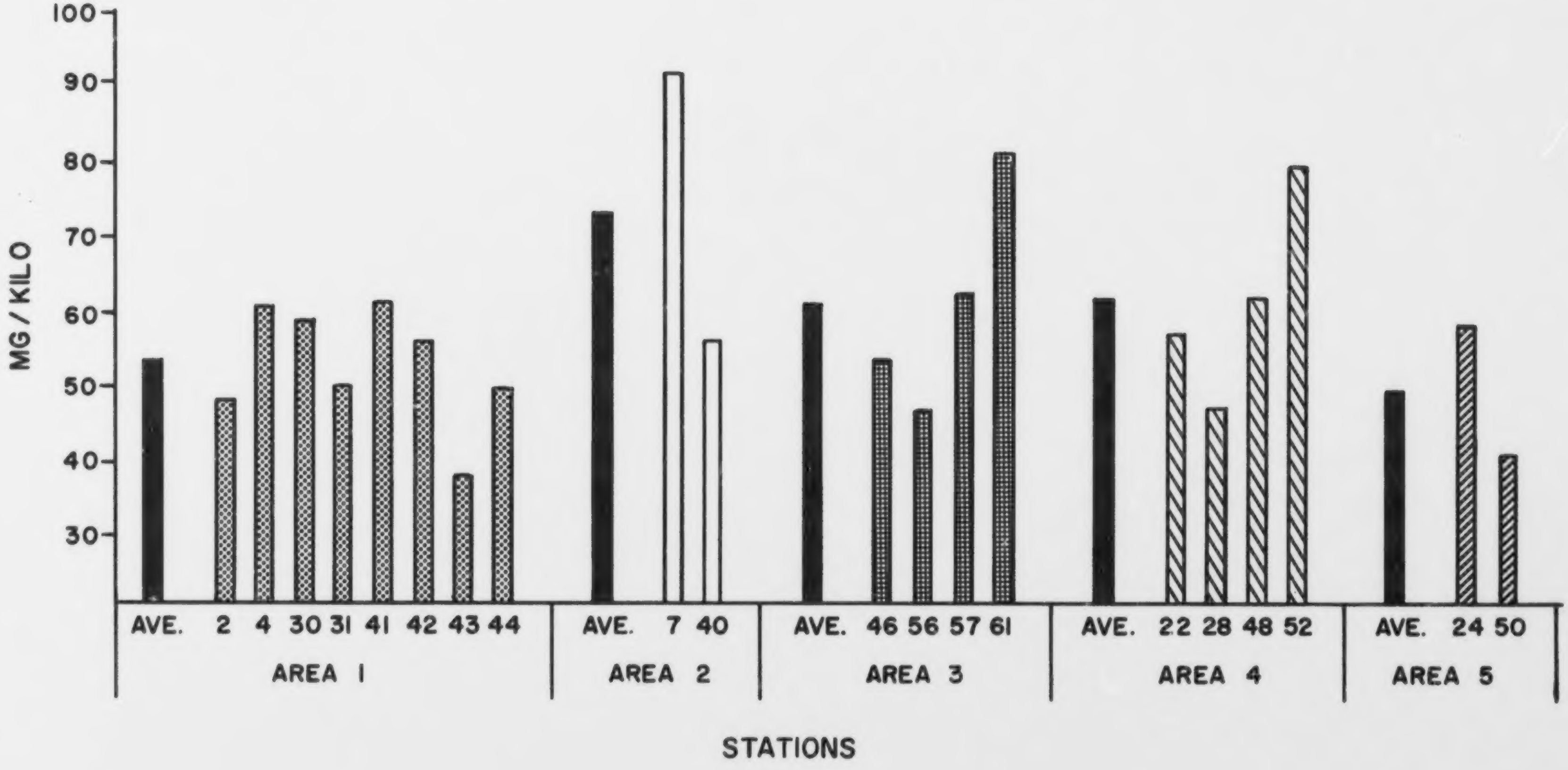


PLATE 13

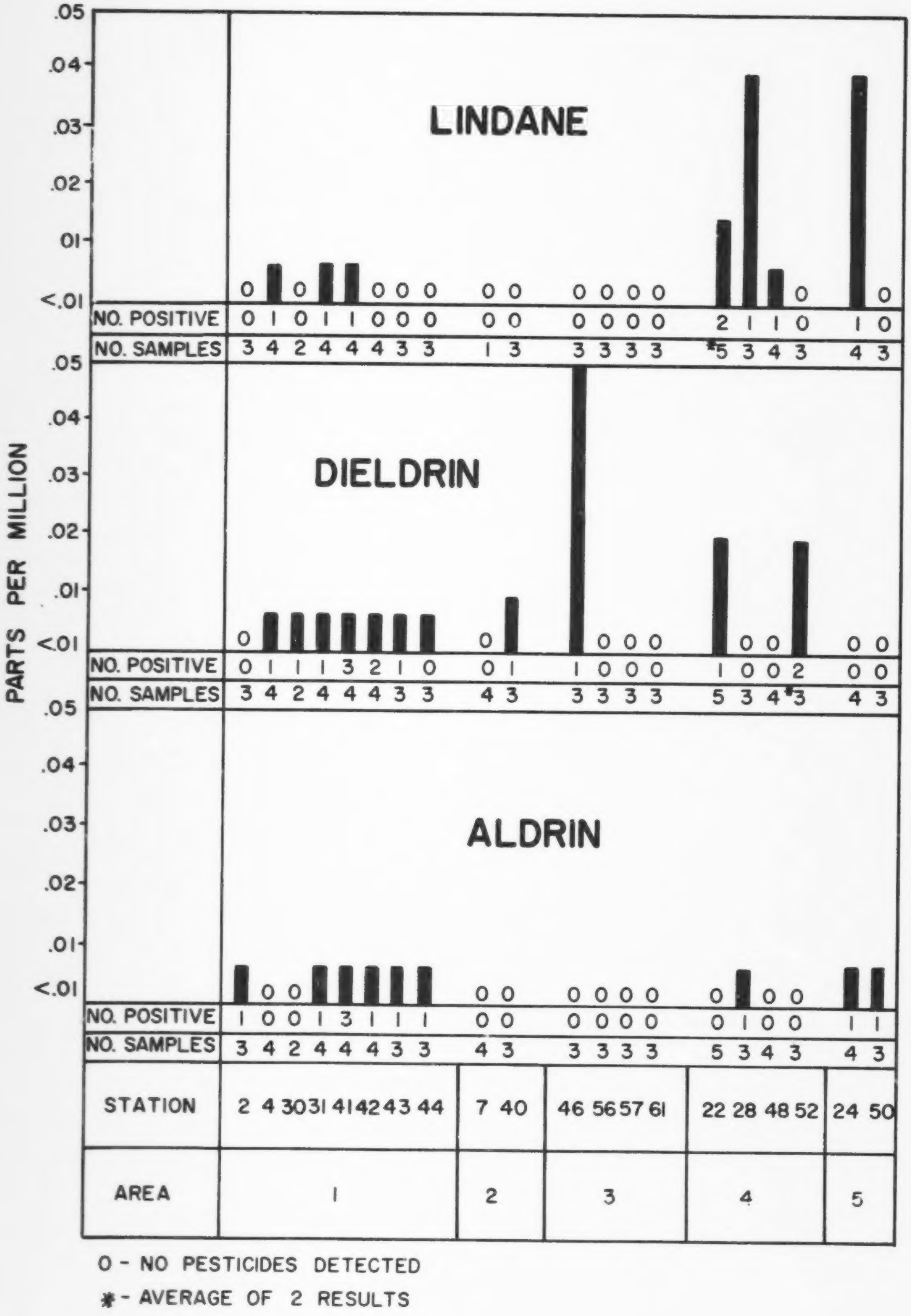

PARTS PER MILLION
.05
.04
.03
.02
.01
<.01
LINDANE
NO. POSITIVE 0 1 0 1 1 0 0 0 | 0 0 | 0 0 0 0 | 2 1 1 0 | 1 0
NO. SAMPLES 3 4 2 4 4 4 3 3 | 1 3 | 3 3 3 3 | *5 3 4 3 | 4 3
DIELDRIN
NO. POSITIVE 0 1 1 1 3 2 1 0 | 0 1 | 1 0 0 0 | 1 0 0 2 | 0 0
NO. SAMPLES 3 4 2 4 4 4 3 3 | 4 3 | 3 3 3 3 | 5 3 4 *3 | 4 3
ALDRIN
NO. POSITIVE 1 0 0 1 3 1 1 1 | 0 0 | 0 0 0 0 | 0 1 0 0 | 1 1
NO. SAMPLES 3 4 2 4 4 4 3 3 | 4 3 | 3 3 3 3 | 5 3 4 3 | 4 3
STATION 2 4 30 31 41 42 43 44 | 7 40 | 46 56 57 61 | 22 28 48 52 | 24 50
AREA 1 | 2 | 3 | 4 | 5
O - NO PESTICIDES DETECTED
* - AVERAGE OF 2 RESULTS

PLATE 14

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